REGISTER

OF THE

BALTIMORE POLYTECHNIC INSTITUTE.

1902-1903.

NEW BUILDING. OLD BUILDING.

Annual Register

—OF THE—

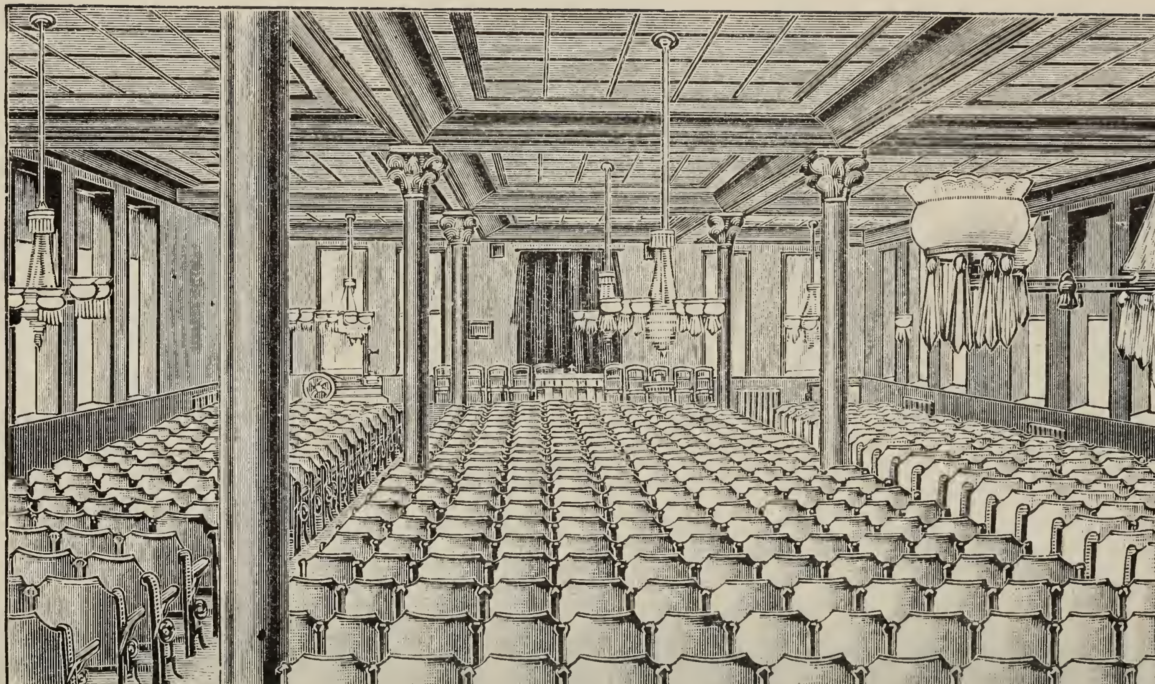
Baltimore Polytechnic Institute

311-331 COURTLAND STREET.

EIGHTEENTH ACADEMIC YEAR,

1902-1903.

Wm. J. C. Dulany Co., Printers,
Baltimore, Md.
1902.



THE ASSEMBLY ROOM.

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BALTIMORE POLYTECHNIC INSTITUTE.

HISTORICAL SKETCH.

The Baltimore Polytechnic Institute, the second manual training school established in the United States as part of a public school system, is one of the several educational institutions of the secondary grade maintained by the city of Baltimore.

Although it is believed that tentative efforts to engraft manual training upon the city's school system were made as early as 1873 or '74, yet the action which led to the establishment of this school was not taken until April, 1883. At a meeting of the Board of Commissioners of Public Schools, held on the 24th of that month, Mr. Joshua Plaskitt, Commissioner for the Ninth ward, offered a resolution for the appointment of a committee "to consider . . . . the advisability of establishing a school or schools for manual training." The resolution was adopted, and the committee thus appointed recommended the establishment of a school "for manual education." The necessary enabling ordinances and enactments having been passed by the City Council of Baltimore and the General Assembly of Maryland, the school was organized and opened on February 26, 1884, under the name "Baltimore Manual Training School," with Dr. Richard Grady as director.

In January, 1886, the faculty was reorganized, Lieut. John D. Ford, an officer of the Engineer Corps of the U. S. Navy, who had been detailed for duty at the school, becoming Principal.

From the opening of the school applicants for admission had been required to pass through the 8th grammar school grade, or to show satisfactory evidence of having had equal

instruction; but in September, 1888, it was decided to admit pupils of the 6th, 7th, and 8th grammar grades. This action opened the school to so large a number of young boys that increased accommodations became imperative, and in June, 1890, the new building, devoted to the academic studies and drawing, was finished and occupied.

Lieut. Ford was recalled to the Naval service in June, 1890, and was succeeded as Principal by John W. Saville, a retired member of the Engineer Corps of the Navy.

In May, 1893, the name of the school was changed to "Baltimore Polytechnic Institute," and the titles of Principal and Vice-Principal to President and Vice-President, respectively.

Mr. Saville resigned in August, 1899, and was succeeded as President by Lieut. William R. King, Engineer Corps, U. S. N., the present head of the school.

The new charter of Baltimore went into effect on March 1, 1900, and under one of its provisions it devolved upon the Mayor, Hon. Thomas G. Hayes, to appoint, as the head of the Department of Education, a Board of School Commissioners composed of nine persons, to serve without pay, and to be chosen from among those citizens he deemed "most capable of promoting the interests of public education, by reason of their intelligence, character, education, or business qualifications." The names of the distinguished citizens so chosen will be found on page 14.

Another provision of the charter requires, that "in order to secure the continuance of local interest in, and over-sight of the public schools, there shall be appointed by said Board of School Commissioners such number of unpaid School Visitors as may be found requisite." In pursuance of this provision, there was appointed as a Board of Visitors to this institution, a group of gentlemen, some of whom are recognized in technical circles throughout the country as being at the head of their respective professions.

The members of the Board of Visitors had no sooner acquainted themselves with the general conditions prevailing

in the school—the age and attainments of the pupils of the lower grades, the character of the work done, and the scope of the curriculum—than they submitted to the Board of School Commissioners a very comprehensive and exhaustive report discussing the condition, needs, and aims of the school, and recommending certain changes in the requirements for admission, and in the curriculum. The partial adoption of this report in September, 1900, excluded grammar school pupils from the institute, thus making the standard for admission the same as that for the City College.

In April, 1901, a further consideration of the report of the Board of Visitors led to the practical addition of one year to the course by permitting graduates to remain for a year of postgraduate work; and in May, 1902, the length of the course was, by action of the Board, set at four years for pupils entering on and after September 15, 1902.

It was further provided that pupils leaving the Institute before the completion of the course should receive certificates of the work done by them up to the time of their withdrawal.

By operation of the new charter the titles of President and Vice-President were changed, in 1900, to Principal and Vice-Principal.

RECORD OF THE FACULTY AND STAFF,

FROM THE ORIGIN OF THE INSTITUTE TO DECEMBER 31, 1902.

The school was organized on February 26, 1884, under the name "Baltimore Manual Training School;" this name was changed in May, 1893, to "Baltimore Polytechnic Institute."

Richard Grady, M.D., D.D.S., Director, February 26, 1884. Services terminated January 11, 1886.

John D. Ford, P. A. Eng., U. S. N., Instructor in Drawing and Steam Engineering, February 26, 1884. Principal, January 11, 1886. Recalled to Naval Service, June 30, 1890.

William Dugent, Instructor in Wood Work, February 26, 1884. Transferred to Pattern Shop, January 11, 1886, and was in charge of that department until September 17, 1900.

J. H. W. Onion, Instructor in Pattern Department, March 1, 1884. Services terminated June 30, 1886.

A. Newton Ebaugh, First Assistant in Academic Department, January 11, 1886. Vice-President, May, 1893. Transferred to Baltimore City College, June 30, 1896, as Professor of History and Political Economy.

C. F. Friese, Instructor in Metal Department, September 1, 1886. Resigned to accept position in Chicago Manual Training School, June 30, 1891.

W. H. Hall, B.C.C., '85, Assistant Instructor in Physics and Chemistry, September 23, 1886. Instructor in Academic Department, June 7, 1898. Head of Department of Physics and Chemistry, September 13, 1899. Head of Department of Science, June 21, 1901.

William G. Richardson, Assistant Instructor in Machine Department, February, 1887. Instructor in Machine Work and Engineering Materials, September 13, 1899.

Andrew J. Pietsch, Assistant Instructor in Academic Department, September 1, 1887. Transferred to be Principal of Male Grrmmar School No. 4, September, 1890.

J. C. McSherry, Assistant Instructor in Academic Department, September, 1887. Resigned, April, 1888.

Richard Piez, B.M.T.S., '87, Instructor in Mechanical Drawing, September, 1887. Resigned, September, 1891.

Lawrence Griffith, Assistant to the Principal and Instructor in Freehand Drawing, September, 1887. Resigned, June, 1890.

John L. Yater, Assistant Instructor in Academic Department, September, 1888. Transferred to be Principal of Annex School No. 14, January, 1899.

Flavius J. Pennington, B.M.T.S., '87, Assistant Instructor in Wood Department, September, 1888. Resigned, April 1, 1889.

David G. Butterfield, Assistant Instructor in Academic Department, September 11, 1888. Transferred to be First Assistant in Male Grammar School No. 20, March 19, 1889.

Thomas G. Ford, B.M.T.S., '88, Assistant Instructor in Wood Department, October, 1888. Assistant Instructor in Carving and Pattern-making, September, 1897. Instructor in Pattern-making and Wood-turning, September 17, 1900, and, in addition, Assistant in Mechanical Drawing, September, 1902.

John T. Robinson, Assistant Instructor in Sheet Metal Department, October, 1888. Resigned to become instructor in Sheet Metal Work at the Brooklyn Polytechnic Institute, Brooklyn, N. Y., June 30, 1894.

J. Ward Willson, M.D., B.C.C., '61, Assistant Instructor in Academic Department, March 21, 1888. Instructor in Academic Department, September, 1898. Instructor in History, Physiology, and German, September 16, 1901. Instructor in German, English, and Science, September, 1902.

George M. Gaither, B.M.T.S., '88, Assistant Instructor in Wood Department, April 1, 1889. Instructor in Carpentry and Carving, September 17, 1900.

Richard H. Uhrbrock, B.C.C., '86, Ph.B., I.W.U., '97, Assistant Instructor in Academic Department, May 15, 1889. Vice-President and Instructor in Mathematics, September, 1896. Head of Department of Mathematics, Septumber 13, 1899. Vice-Principal, June 21, 1901.

John W. Saville, P. A. Eng., U. S. N. (retired), Principal and Instructor in Steam Engineering, September, 1890. President and Instructor in Steam Engineering, May, 1893. Resigned, August 31, 1899.

Edward S. Kines, B.C.C., '90, Assistant Instructor in Academic Department, September, 1890. Resigned, October 1, 1894.

J. Henry Laessig, Assistant to Principal and Instructor in Mechanical Drawing, September, 1890. Resigned, June 30, 1893.

Eason Lewis, Lieut. U.S.A., Instructor in Military Drill and Assistant Instructor in Academic Department, November, 1890. Recalled to U. S. Army, April, 1891.

Albert McClean, Instructor in Forge Work, September, 1891. Resigned, January, 1898.

Warren S. Seipp, B.M.T.S., '91, Instructor in Free-hand Drawing, September, 1891. Instructor in Free-hand Drawing and Carpentry, November, 1901. Instructor, Manual Training Centre No. 1, June, 1902.

B. Wheeler Sweany, Instructor in Mechanical Drawing, September, 1892. Transferred to Baltimore City College as Professor of Drawing, October 1, 1897.

Joseph F. McBee, Assistant Instructor in Academic Department, September, 1893. Transferred to be Principal of Annex School No. 14, June, 1894. Re-transferred to the Baltimore Polytechnic Institute as Assistant Instructor in Academic Department, January, 1899. Dismissed, May, 1899.

Nathaniel D. D. Sollers, Assistant Instructor in Academic Department, September, 1893. Resigned, June, 1894.

F. D. J. Kaessmann, Assistant Instructor in Academic Department, September, 1893, until September, 1901.

William A. Jones, Assistant Instructor in Sheet Metal Department, September, 1894. Instructor in Sheet Metal Department, September, 1898. Instructor in Forge and Sheet Metal Work, September 17, 1900.

Samuel M. North, B.C.C., '87, Assistant Instructor in Academic Department, September, 1894. Instructor in Academic Department, September, 1898. Head of Department of English, September 13, 1899. Head of Department of English, including History and Language, June 21, 1901.

Joseph C. O'Connor, Assistant Instructor in Carpentry, September, 1894. Resigned, June 30, 1897.

Henry Sanders, Instructor in Sheet Metal Department, September, 1894. Resigned, November 30, 1894.

William S. Blake, B.C.C., '94, Assistant Instructor in Academic Department, October 1, 1894. Transferred to Male Grammar School No. 1, January, 1899.

Ralph L. Williams, B.P.I., '93, Assistant Instructor in Academic Department, October 1, 1894. Lost at sea, July 4, 1898.

Frederick W. Wild, Instructor in Sheet Metal Department from December 1, 1894, to September 17, 1900.

B. Harrison Branch, B.M.T.S., '92, Assistant Instructor in Academic Department and Assistant in Machine Department, October, 1896. Resigned, April, 1898.

Samuel P. Platt, Instructor in Mechanical Drawing and Descriptive Geometry, October 1, 1897.

J. C. Mattoon, B.M.T.S., '90, Assistant Instructor in Academic Department, November 1, 1897. Resigned, February, 1898.

Oliver Bacharach, B.C.C., '97, Assistant Instructor in Academic Department, April, 1898. Assistant Instructor in Mathematics, September 16, 1901.

William P. Gundry, B.M.T.S., '90, Assistant Instructor in Academic Department, April, 1898. Resigned, December 31, 1901.

J. Edward Broadbelt, Ph.G., B.M.T.S., '90, Assistant Instructor in Academic Department, September, 1898. Secretary and Assistant Instructor in Science, September 16, 1901.

John H. DeValin, Instructor in Forge Work from September, 1898, to September 17, 1900.

William R. King, Passed Assistant Engineer, U. S. N. (retired), U. S. N. A., '75, President and Instructor in Engineering and Applied Mechanics, September 1, 1899. Principal and Head of Department of Engineering, June 12, 1901.

John H. Bramble, B.C.C., '96, Assistant Instructor in Academic Department, October, 1899. Assistant Instructor in Mathematics and Science, September 16, 1901. Assistant Instructor in Mathematics, September 15, 1902.

John Montgomery Gambrill, B.P.I., '97, Instructor in History, Civics, and Literature, June 11, 1902.

Charles Ernest Conway, B.P.I., '02, Assistant in Department of Engineering and Applied Mechanics, June 11, 1902.

BOARD OF SCHOOL COMMISSIONERS.

JOSEPH PACKARD, *President*,
THOMAS S. BAER,
DR. IRA REMSEN,
ALCAEUS HOOPER,
REV. WILLIAM ROSENAU,
CHARLES H. EVANS,
JAMES H. PHILLIPS,
COL. A. B. CUNNINGHAM,
THOMAS McCOSKER.

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FREDERICK W. WOOD,
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GUSTAVUS W. LEHMANN,
JAMES L. MURRILL,
WILLIAM H. ROTHROCK,
MENDES COHEN.

SUPERINTENDENT OF PUBLIC INSTRUCTION.

JAMES H. VAN SICKLE.

Calendar for School Year 1902-1903.

September 15, Monday	Opening of Session.
November 24, Monday	Second Quarter begins.
November 27, Thursday	Thanksgiving Day.
December 23, Tuesday	Christmas Vacation begins.
January 5, Monday	Christmas Vacation ends.
January 19 to February 9	Semi-annual Examinations.
February 2, Monday	Third Quarter begins.
April 9, Thursday	Easter Vacation begins.
April 13, Monday	Easter Vacation ends.
April	Arbor Day.
April 27, Monday	Fourth Quarter begins.
May 25	Annual Examination begin.
June 23, Tuesday	Commencement Day.
September 14, Monday	Opening of Session.
November 23, Monday	Second Quarter begins.
November 26, Thursday	Thanksgiving Day.
December 23, Wednesday	Christmas Vacation begins.

FACULTY.

WILLIAM R. KING, U. S. N., *Principal*
and
Head of Department of Engineering.

RICHARD H. UHRBROCK, Ph.B., *Vice-Principal*
and
Head of Department of Mathematics.

WILLIAM H. HALL,
Head of Department of Science.

SAMUEL M. NORTH,
Head of Department of English, including History and Language.

STAFF.

JOHN WARD WILSON, M.D.,
German, English Composition, and Science.

SAMUEL P. PLATT,
Mechanical Drawing and Descriptive Geometry.

OLIVER BACHARACH,
Mathematics.

JOHN H. BRAMBLE,
Mathematics.

JOHN EDWARD BROADBELT, Ph.G.,
Secretary and Science.

JOHN MONTGOMERY GAMBRILL,
History, Civics, and Literature.

CHARLES E. CONWAY,
Engineering and Practice.

GEORGE P. VON EIFF,
Graduate Assistant in Physical Laboratory.

MECHANICAL DEPARTMENT.

WILLIAM G. RICHARDSON,
Machine Work and Engineering Materials.

THOMAS G. FORD,
Pattern-Making, Wood-Turning, and Mechanical Drawing.

WILLIAM A. JONES,
Forge and Sheet Metal Work.

GEORGE M. GAITHER,
Carpentry and Wood-Carving.

COURSE OF STUDY AND GENERAL STATEMENT OF PLAN AND PURPOSE.

The course of study for the Baltimore Polytechnic Institute is designed to accomplish the following purposes :

1. To give a sound fundamental education to pupils whose inclinations and other circumstances preclude a college course.

2. To give to youth that healthful and highly valuable manual training which broadens education, and conduces to dexterity, contrivance, and invention.

To this end the time usually devoted to Greek and Latin is employed, during two years of the course, in carpentry, sheet-metal, and light forge exercises. These exercises cover what is known as manual training, and are given with special reference to their educational value.

3. To give to students in the third and fourth years such studies in Mathematics, Physics, and Chemistry, and such mechanical exercises in Applied Manual Training, as will fit them :

(*a*) For teaching in Manual Training Schools.

(*b*) For immediate and remunerative employment in the drafting room, or for engagements in the wide field of electrical and mechanical engineering, where, it is believed, their training will lead to rapid advancement.

(*c*) For entrance to advanced standing into an institution of technology, should a higher technical education be desired.

For the attainment of these objects there is one carefully planned general course of study, no effort being made to specialize until the fourth year, by which time a student will have acquired a considerable degree of practical skill and intimate knowledge in some one of the professions based on mechanical art and applied science that he may have elected to follow. Thus, for example, the student who may, toward the end of the course, elect to follow electrical engineering as

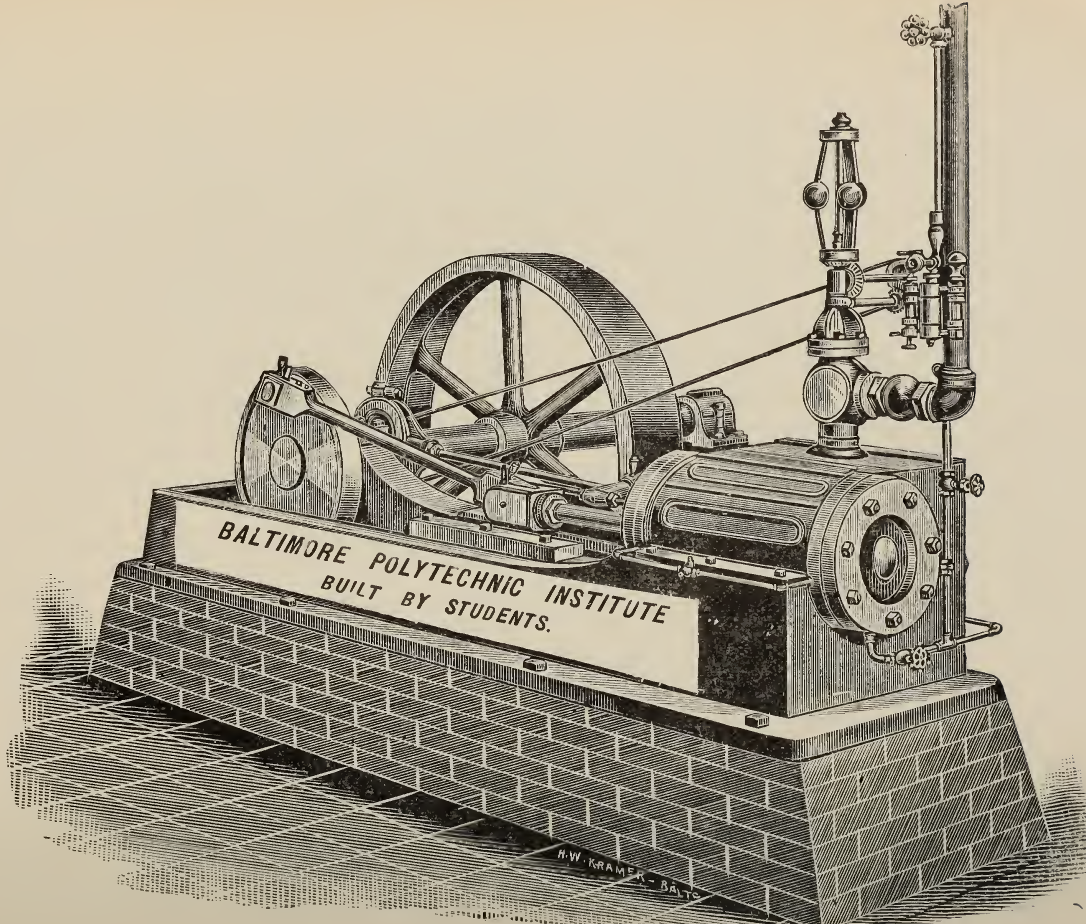
a profession, will be afforded special opportunities for laboratory practice in the manipulation of currents, methods of testing, etc. The student who elects to follow mechanical or steam engineering as a life work, studies the elements of the theory of constrnction and operation of machines, special attention being given to the theory of the steam engine. In the drawing room he is given elementary work in engine and machine design, and in the shops he does some actual work in engine and machine building.

No attempt is made to teach trades, but the equipment is of such a nature that the instruction given in the shops is designed to be correlative to the work of the class-room, and results are aimed at that will insure success in mechanical pursuits subsequent to graduation. It is believed that instruction in correct methods of using tools, and practical illustrations of how, and for what purpose, things are done, are of more value than mere excellence in hand skill.

Instruction in the English Department is given during the first, second, and third years, and embraces Composition, Rhetoric, Literature, History, and Civics. Special effort is made to inculcate sound principles in the choice of words and in phraseology, and frequent written exercises in the various kinds of composition are required of the student. The first year work in History is followed in the second year by a course in Civics, which is designed to ground the student in the fundamental principles of government and to emphasize their application to American citizenship.

The instruction in German during the second and third years, and in French during the fourth year, is designed to give a reading, rather than a speaking knowledge of these languages, in order to meet entrance requirements of institutes of technology.

In Mathemetics, care is taken at the beginning of the first year to discover and correct any defects in fundamental training, after which the course of instruction proceeds in Algebra, Geometry, Trigonometry, and Analytical and Descriptive Geometry. During the fourth year the instruction


BALTIMORE POLYTECHNIC INSTITUTE
BUILT BY STUDENTS.
H.W. KRAMER - BALTO

given in the Engineering Department in Dynamics and Thermo-dynamics involves in its very elements the use of equations and mathematical principles which can be understood only by resort to the calculus. For this reason instruction in the Differential and Integral Calculus is indispensable. The course is sufficiently broad to fit students for more advanced work, and includes the fundamentals of differentiation and integration, the development of the theorems of Taylor and Maclaurin, and applications of the subject to questions of maxima and minima, areas, volumes, and moments of inertia. Without such instruction, a student at graduation will be unable to read understandingly a treatise on any of the mechanical sciences.

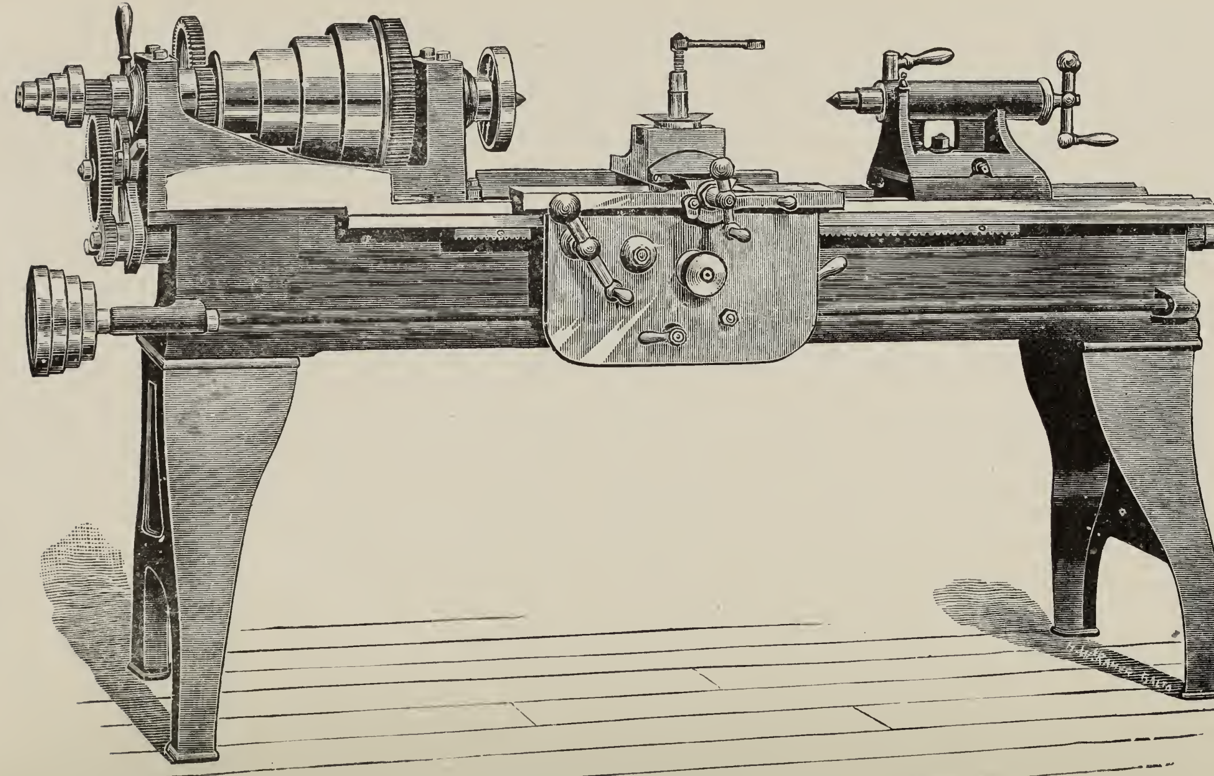
In Physics, the work of the first and second years embraces the properties of matter and elementary mechanics, the instruction being accompanied with lectures illustrated by experiments, and with practical work in the laboratory. The instruction of third and fourth year students in this subject is confined to Heat and Electricity. The dynamic theory of heat, the conversion of heat into mechanical work, and the thermodynamics of the steam engine are the particular features of the fourth year in the study of Heat.

In Electricity, the work of the fourth year conists of practical applications of the theoretical study of the second and third years, and of commercial electricity. Electric lighting, both arc and incandescent, is discussed from constructive and economic standpoints, especially high and low voltage distribution. The dynamo and motor are treated in detail—operating, designing, and winding being carefully considered. The experimental equipment for this work consists of a twenty-five kilowatt generator, built by the students ; a one-half horsepower alternating current motor coupled to a twenty-five volt multipolar generator; and several smaller machines of various types. These appliances, with the electric light equipment of the Institute, present opportunities for personal observation and operation of electrical machinery and the various defects and faults to be overcome. Alternating cur-

rents are treated both mathematically and experimentally, and converters, motors, impedance coils, and measuring instruments are used by students for verifying laws and descriptions given in lectures. The main and laboratory switchboards and the generating plant afford opportunities for power-station practice, and the electric railway is treated in a practical manner. The newest and best methods of telegraph and telephone construction are presented, the telephones of the Institute being installed on the central-energy plan. Special features of the course are the various tests for insulation resistance of conductors, the tests for grounds, faults, and short circuits on lines, and a treatment of the defects in the dynamo and motor, and remedies therefor.

For the study of Chemistry there are chemicals and apparatus in the laboratory to give to the third-year students instruction concerning the nature and reactions of the chemical elements and their compounds, and to students of the fourth year a brief course in qualitative and quantitive analysis, the compounds formed in the various reactions and their chemical equations being particularly emphasized.

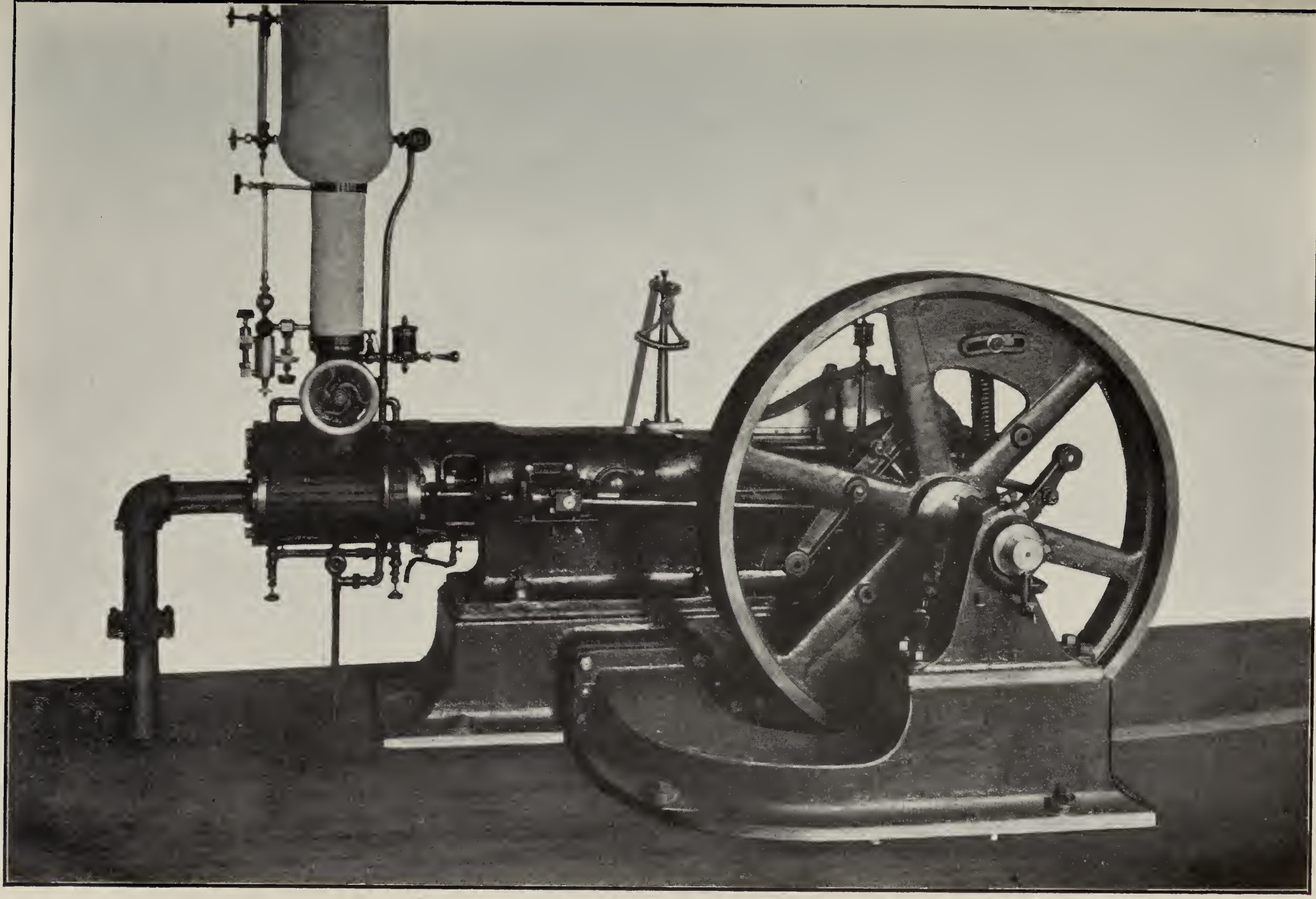
In the Department of Engineering the instruction given the fourth year students in theoretical and applied mechanics, which extends well into the Sophomore year of an institute of technology, embraces the laws of equilibrium and motion; centre of gravity; friction; principles of work; moments of inertia; mechanics of materials; and an elementary study of the stresses and deformations produced in standard specimens of metals when subjected to tension, compression, and shearing. The work of the third and fourth year students in steam engineering consists of the study of the thermodynamics of the steam engine in as comprehensive a manner as the facilities of the Institute and the maturity of the students permit. Numerous calculations are made involving engine and boiler efficiencies and proportions, and the study of the indicator is supplemented with practice in taking diagrams, from which the consumption and distribution of the steam, and the power of the engine are determined. The advantages and disadvan-



BUILT BY STUDENTS.

tages of the different kinds of steam boilers are studied, particular attention being given to such attachments as separators, feedwater heaters, and mechanical stokers. The plant for this work consists of an inverted compound engine of 60 I. H. P., an inverted triple expansion engine of 100 I. H. P., and a high speed automatic cut-off engine (Harrisburg Standard) of 46 I. H. P., and a Campbell & Zell sectional boiler of 100 horsepower. The engines mentioned above were built by the students, the first two after designs of the Bureau of Steam Engineering of the Navy Department. In the mechanical drawing room are seventy-five tables of approved design, and an equipment of instruments and models well adapted to the requirements of an advanced course in the subject. Fourth year students are required to make a free-hand sectional sketch of some machine, from which a finished drawing, tracing, and blue print are made, and their work in design tends to make them draftsmen in the truest sense—not mere copyists.

The material equipment in the machine, pattern, forge, sheet-metal, and carpentry shops is equal, and in some respects superior, to that of any similar institution in the country.



HIGH SPEED AUTOMATIC CUT-OFF ENGINE (HARRISBURG STANDARD).
Built by Classes of 1901 and 1902.

THE COURSE OF INSTRUCTION IN DETAIL.

NOTE.—Pupils who complete the four-year course as here outlined, and are recommended, will be admitted without examination to full Sophomore standing in the course leading to the degree of Mechanical Engineer or Electrical Engineer, at Sibley College, Cornell University.

Five members of the class of 1902, availing themselves of this privilege, entered Cornell last September. The following letter bears testimony as to the character of the preparation they received:

SIBLEY COLLEGE, CORNELL UNIVERSITY.
R. H. THURSTON, *Director*.

FACULTY OF MECHANICAL ENGINEERING.
W. F. DURAND, *Secretary*.

ITHACA, N. Y., *September 29, 1902*.

WILLIAM R. KING, U. S. N.,
Principal, Baltimore Polytechnic Institute, Baltimore, Md.

DEAR SIR:

The five boys referred to in yours of the 19th inst. arrived on time and were duly entered. They passed up the full Freshman year and received a little credit on some of the Sophomore work. They are in excellent shape to complete our course in three years' time which, I have no doubt, they will do with credit to themselves and to their training in your school.

Sincerely yours,
W. F. DURAND.

DEPARTMENT OF ENGINEERING AND APPLIED MECHANICS.

FIRST YEAR COURSE—D CLASS.

Lectures and Practical Exercises.

(*a*) *Carpentry*.—16 weeks, 6 periods a week.

(*b*) *Sheet Metal*.—16 weeks, 6 periods a week.
Soldering; sheet metals; Venetian iron and repousse work.

(*c*) *Mechanical Drawing*.—32 weeks, 4 periods a week.
Use of instruments; lettering; elementary lessons.

SECOND YEAR COURSE—C CLASS.

Lectures and Practical Exercises.

(*a*) *Review of Carpentry.*—4 weeks, 6 periods a week.
(*b*) *Introductory Vise Work.*—4 weeks, 6 periods a week.
(*c*) *Forge.*—12 weeks, 6 periods a week.
Light forging and welding.
(*d*) *Pattern.*—12 weeks, 6 periods a week.
(*e*) *Mechanical Drawing.*—32 weeks, 5 periods a week.
Hatching; tinting; neatness and accuracy; scale drawing.

THIRD YEAR COURSE—B CLASS.

Steam and the Steam Engine.—32 weeks, 4 periods a week.

Early history and progress of steam engineering; combustion of fuel and steam generation; efficiency; economy of fuel; the indicator; horse power; the slide valve.

Mechanical Drawing.—32 weeks, 4 periods a week.

Detail drawings of machines from free-hand sketches; the working drawing, tracing, and blue print. Descriptive Geometry (see course in Mathematics).

Practice.—(*a*) Pattern Shop; 16 weeks, 6 periods a week.

Exercises in making patterns for wrenches, pulleys, eccentrics, pillow-blocks, gears, globe valves, pipe joints, and core boxes where necessary.

Lectures on construction and finish of patterns; green sand molding, open sand molding, loam molding, mixing of iron and of brass, and on the operation of the cupola.

(*b*) Machine Shop, Forge Shop, and Laboratory; 16 weeks, 6 periods a week.

Work at the lathe, planer, milling machine, drill-press, and vise. Forging and tempering machine cutting tools; casehardening; chasing. Valve setting; operating engines and taking indicator diagrams.

FOURTH YEAR COURSE—A CLASS.

Lectures and Recitations.—32 weeks, 3 periods a week.

Steam and the Steam Engine.—Thermodynamic applications; the laws of Charles and Boyle; kinetic theory of heat; absolute zero of temperature; the expansion of gases, with particular reference to different conditions of steam expansion; details of steam engine; link motion; clearance and compression; indicator diagrams—theoretical and actual; steam consumption per unit of power; mean effective pressure; stage expansion engines; condensers; boilers; engineering materials; calorimeter tests for determining the quality of steam.

Mechanics.—32 weeks, 3 periods a week.

First Principles.—Matter; mass; inertia; velocity; acceleration; force; absolute measure of force; gravity; gravitation units of measure; comparison of gravitation and absolute measure of force.

Kinematics.—Motion in a straight line with a constant acceleration; falling bodies; resolution and composition of velocities; the conversion of motion; harmonic motion; velocity ratios.

Dynamics.—(*a*) Statics.—The parallelogram, triangle, and polygon of forces; composition and resolution of forces; conditions of equilibrium; transmissibility of force; parallel forces; moments of forces and of couples; conditions of equilibrium of a body under the action of three forces in one plane; centre of gravity; friction; virtual velocities; the mechanical powers. (*b*) Kinetics.—The laws of motion; centripetal and centrifugal forces; kinetic energy, or vis viva, of a moving body; work.

Mechanics of Materials.—Stress; strain; elastic limit; ultimate strength; bending and resisting moments; moment of inertia; radius of gyration; simple and cantilever beams; struts; deflection; torsion; resilience; bending-moment and shear diagrams.

Design and Mechanical Drawing.—32 weeks, 4 periods a week.

Design.—Some part of an engine or of a tool, such as cylinder, connecting rod, valve, screw-jack; Zeuner diagram.

Mechanical Drawing.—The drafting accompanying the work in design; free-hand sketches, from which are made the finished drawing, the tracing, and the blue print.

Practice.—32 weeks, 4 periods a week.

Actual running and indicating of steam engines; testing for tension, compression, and flexure with a Riehle machine; machine work involving accuracy and finish.

DEPARTMENT OF MATHEMATICS.

FIRST YEAR COURSE—D CLASS.

Explanation and Demonstration.—32 weeks, 2 periods a week.

The most difficult and important features of the course are explained and demonstrated by the instructors.

Algebra.—32 weeks, 4 periods a week.

Inequalities; indeterminate linear equations; involution; evolution; surds; imaginary and complex numbers; doctrine of exponents; the reduction and solution of quadratic equations; ratio and proportion; arithmetical, geometrical, and harmonical progressions; permutations; combinations; binomial theorem.

Plane Geometry.—32 weeks, 3 periods a week.

Geometry of the straight line and circle; proportion; properties of similar figures; areas; regular polygons; original exercises.

SECOND YEAR COURSE—C CLASS.

Solid Geometry.—16 weeks, 3 periods a week, and 16 weeks, 2 periods a week.

Lines and planes in space; polyhedrons; cylinder; cone; sphere; original exercises.

Advanced Algebra.—16 weeks, 3 periods a week.

Comprehensive review of the work of the preceding year; variables and limits; infinite series; partial fractions; binomial theorem; logarithmic usage; summation of series; exponential and logarithmic series.

Plane Trigonometry.—16 weeks, 4 periods a week.

Functions of the acute angle; the right triangle; use of tables; goniometry.

THIRD YEAR COURSE—B CLASS.

Plane Trigonometry.—10 weeks, 3 periods a week.

The oblique triangle; miscellaneous examples.

Spherical Trigonometry.—12 weeks, 3 periods a week.

The right spherical triangle; the oblique triangle; applications of spherical trigonometry.

Surveying.—10 weeks, 3 periods a week.

Instruments and their uses; land surveying.

Analytic Geometry.—32 weeks, 4 periods a week.

The straight line; circle; parabola; ellipse; hyperbola; transformation of co-ordinates; construction of loci; higher plane curves.

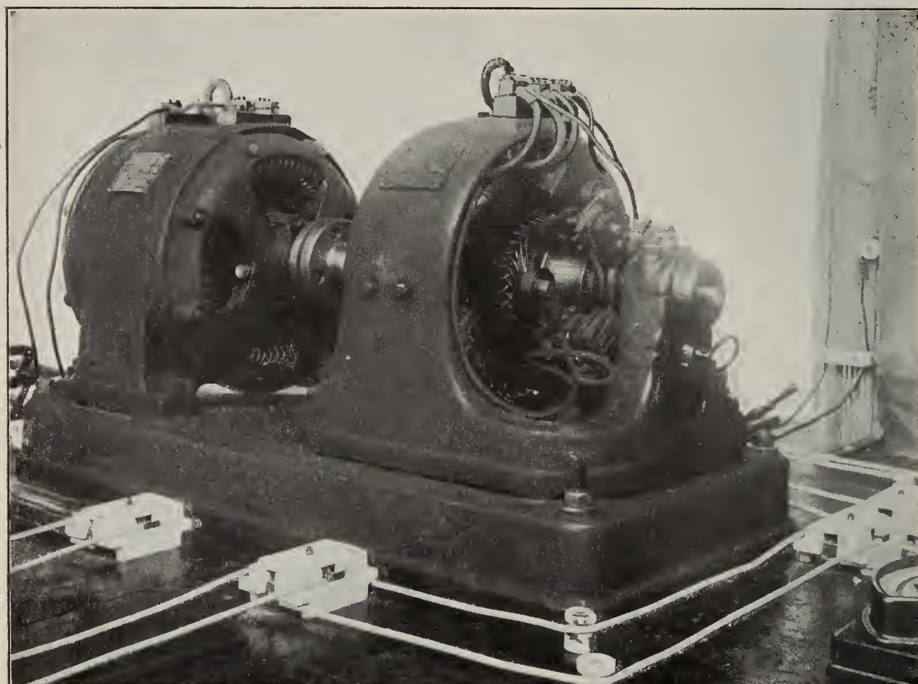
Descriptive Geometry.—Time taken from Mechanical Drawing, as the subject is taught in conjunction with that subject.

Projections: problems in straight line and plane; projections and sections of solids; curved surfaces and tangent planes; development and projection of screw threads; intersection of surfaces.

FOURTH YEAR COURSE—A CLASS.

Differential and Integral Calculus.—32 weeks, 5 periods a week.

Differentiation of algebraic and of transcendental functions; successive differentiation; expansion of functions, including the development of Maclaurin's and of Taylor's theorems; evaluation of indeterminate forms; mode of variation of functions of one variable, including geometric problems in maxima and minima; differentiation of functions of more than one variable; tangents and normals; derivatives of arcs, areas, volumes, and surfaces of revolution; circle of curvature; radius of curvature; fundamental rules and methods of integration; geometrical applications of the calculus to lengths of curves, to areas, to volumes of solids of revolution; integration of trigonometric functions; successive integration; applications to mechanics.



WESTINGHOUSE MOTOR-GENERATOR.
Used in Laboratory.

DEPARTMENT OF PHYSICS AND CHEMISTRY.

FIRST YEAR COURSE—D CLASS.

General Physics.—32 weeks, 2 periods a week.

Properties of matter; C. G. S. units; falling bodies; work and power; elementary mechanics; specific gravity; elements of hydro-mechanics; pressure and expansion of air; lectures illustrated by experiments; practical work in laboratory.

SECOND YEAR COURSE—C CLASS.

Heat.—32 weeks, 2 periods a week.

Thermometers; calorimetry; co-efficients of expansion; boiling points; distillation; latent heat; laws of thermodynamics; mechanical equivalent of heat.

Electricity.—32 weeks, 2 periods a week.

Magnetism; currents; induction; static electricity; lectures and experiments; practical work in laboratory.

THIRD YEAR COURSE—B CLASS.

Electricity.—32 weeks, 3 periods a week.

Deduction of formulæ; use of galvanometer; magnet testing; laws of induction; simple alternating currents; relation of electricity to work and power; practical work in laboratory.

Chemistry.—32 weeks, 2 periods a week.

Recitations in general chemistry; experiments illustrating text.

FOURTH YEAR COURSE—A CLASS.

Electricity.—32 weeks, 4 periods a week.

Lectures and recitations in applied electricity, including electro-chemical action; principles of the dynamo, motor, and transformer; railways; line and machine testing; telegraph and telephone; electric lighting; practical work in laboratory.

Chemistry.—32 weeks, 4 periods a week.

Theory of analysis; qualitative analysis of solutions containing one base and one acid; qualitative analysis of solution containing several salts; qualitative analysis of powders; quantitative analysis of lead solution by volumetric method; quantitative analysis of silver solution by gravimetric method; simple analysis for carbon in iron and steel; formulæ for all reactions.

DEPARTMENT OF ENGLISH, INCLUDING HISTORY AND LANGUAGE.

FIRST YEAR COURSE—D CLASS.

Composition and Rhetoric.—32 weeks, 2 periods a week.

Study of text and frequent written exercises in Paragraphing and Sentence Structure, based upon Narration and Description; Letter Writing.

Literature.—32 weeks, 2 periods a week.

(*a*) Leading facts in the lives of representative American writers.

(*b*) Reading and study in class of the following selections: Legend of Sleepy Hollow, Forest Hymn, Tales of a Wayside Inn, The Gold Bug, Snow-bound, Vision of Sir Launfal, Selections from Holmes

History.—32 weeks, 3 periods a week.

The course includes Greek and Roman history, and the subjects are taught both chronologically and topically.

SECOND YEAR COURSE—C CLASS.

Composition and Rhetoric.—32 weeks, 2 periods a week.

Study of text and frequent written exercises upon the Sentence, the Paragraph, and the Whole Composition.

Literature.—32 weeks, 2 periods a week.

(*a*) Leading facts in the lives of representative English writers since Pope's time.

(*b*) Study in class of the following texts: Vicar of Wakefield, Ivanhoe, Silas Marner, The Princess, The Ancient Mariner.

German.—32 weeks, 3 periods a week.

Study of the grammar, and reading.

Civics.—32 weeks, 1 period a week.

The principles of government and their applications to American citizenship.

THIRD YEAR COURSE—B CLASS.

Literature.—32 weeks, 2 periods a week.

Study of the works selected for 1903 by the Committee on Uniform Entrance Requirements. The works prescribed are Macbeth, Macaulay's Essays on Milton and Addison, Burke's Speech on Conciliation with America, and Milton's Comus, Lycidas, Il Penseroso, and L'Allegro.

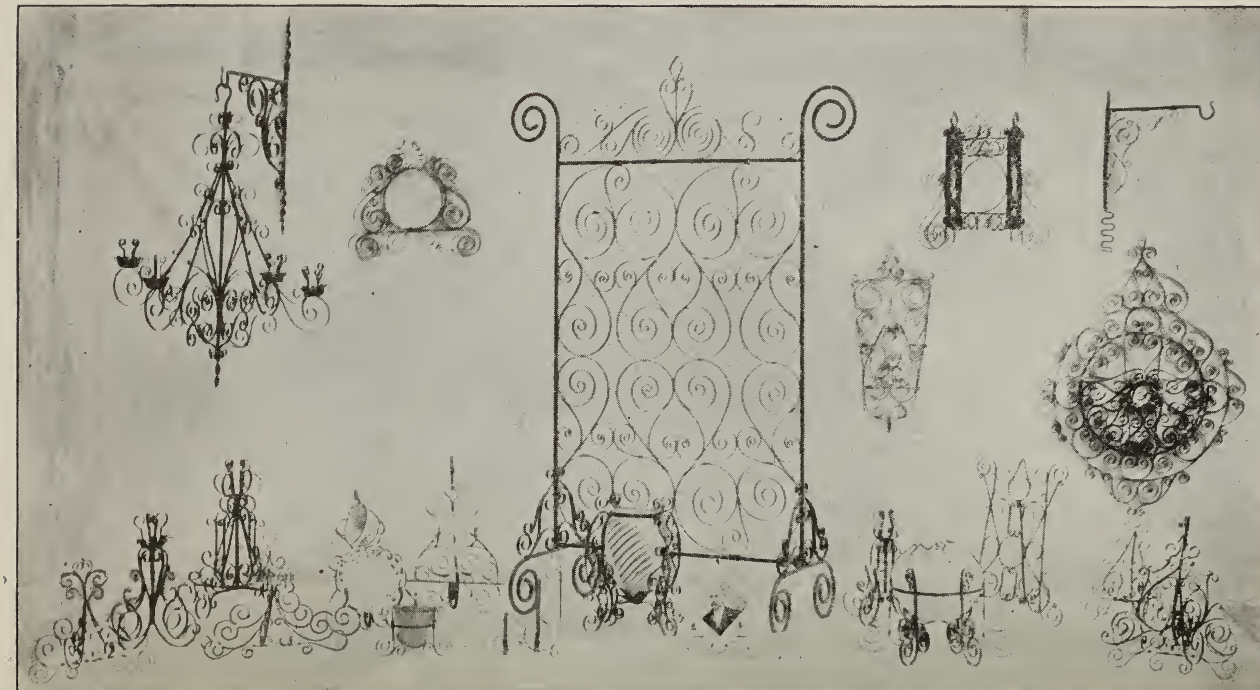
German.—32 weeks, 2 periods a week.

Composition, and reading easy prose on scientific topics.

FOURTH YEAR COURSE—A CLASS.

French.—32 weeks, 2 periods a week.

Study of the grammar and reading simple prose science.



VENETIAN IRON WORK.

REQUIREMENTS FOR ADMISSION.

Pupils bearing properly attested certificates of having passed the prescribed Grammar School Course of the Public School System of Baltimore are entitled to enrollment.

Other applicants residing in the city will be admitted after passing an examination covering the requirements of the eighth grammar school grade. Eighth grade grammar school pupils who failed of promotion are not eligible for admission under this requirement. Specimen entrance examination papers covering the requirements of the eighth grade will be found on pages 59 and 60.

Non-resident applicants, in addition to passing the entrance examination, are required to pay an annual fee of $72.00, charged for tuition and for the use of books.

After having successfully passed the entrance examination, a non-resident applicant must register as such at the office of the Secretary of the Board of School Commissioners, where he will be furnished with a bill for the first quarterly installment of the fee; and a presentation at the Institute of a coupon from the bill, signed by the City Comptroller, will be accepted as evidence of payment, and entitle the applicant to enrollment.

MERIT ROLLS.

Merit rolls, showing the proficiency of students in each branch of study, are made out annually for the different classes

Each subject is assigned a coefficient indicative of its relative weight; and the final mark of a student in a subject (on a scale of 100) is multiplied by its coefficient. The sum of the products is the final mark of the student for the year. This mark is a certain percentage of the sum of the coefficients, and such percentage is the student's average for the year.

TIN WORK.

BALTIMORE POLYTECHNIC INSTITUTE

FINAL MERIT ROLL AND FOURTH YEAR RECORD OF GRADUATING CLASS OF 1902.

Order of Merit.	NAMES.	Date of admission.	Mechanics.	Mechanics of Materials.	Steam Engineering.	Mech. Drawing and Design.	Diff. and Integral Calculus.	Chemistry.	Applied Electricity.	French.	Practice.	Conduct.	Aggregate. for 4th Year.	Aggregate for 3rd Year.	Aggregate for 2nd Year.	Aggregate for 4th, 3rd, & 2nd Yrs.	Graduating Average.
	MAXIMA		7	10	10	8	10	10	10	5	5	5	80	60	40	180	100
5	J. M. Beehler......	1895	No. 5 5.60	No. 5 9.00	No. 5 8.50	No. 5 6.96	No. 4 8.50	No. 7 8.60	No. 3 9.30	*	No. 4 4.75	No. 4 3.25	64.46	53.16	35.22	152.84	84.89
4	C. E. Conway......	1898	No. 4 5.95	No. 4 9.10	No. 4 8.90	No. 2 7.20	No. 5 8.20	No. 1 9.40	No. 6 8.80	*	No. 2 4.80	No. 1 5.00	67.35	52.10	35.89	155.34	86 30
[redacted]	I. C. Hess..	1896	No. 6 5.11	No. 7 7.80	No 5 8.50	No. 6 6.88	[redacted]	No. 5 9.10	No. 5 8.90	*	No. 6 4.65	No. 3 4.40	55.34	51.56	35.55	142.45	79.14
1	A. J. Lowndes.....	1898	No. 1 6.65	No 3 9.20	No 1 9.40	No. 1 7.76	No. 3 8.70	No. 3 9.30	No. 2 9.40	No. 3 4.30	No. 1 4.90	No. 1 5.00	74.61	55.24	36.18	166.03	92.24
6	A. J. Malone.......	1898	No. 7 5.04	No. 8 7.70	No. 7 8.20	No. 9 6.64	No. 7 7.40	No. 6 9.00	No. 8 7.90	No. 4 3.95	No. 8 4.55	No. 2 4.50	64.88	51.06	34.23	150.17	83.43
3	J. A. Raidabaugh..	1896	No. 3 6.30	No. 1 9.30	No 3 9.20	No. 3 7.12	No. 1 9.50	No. 2 9.40	No. 1 9.50	No. 1 4.70	No. 5 4.70	No. 1 5.00	74.72	53 74	35.84	164.30	91.28
8	S. C. Vincent......	1895	No. 9 4.55	No 9 6.90	No. 8 7.80	No. 8 6.72	No. 8 7.40	No. 8 8.10	No. 7 8.00	No. 5 3.60	No. 9 4.50	No. 1 5.00	62.57	45.50	33.93	142.00	78.89
7	G. P. Voneiff......	1895	No. 8 4 90	No. 6 7.80	No. 9 7.40	No. 7 6 80	No. 6 7.50	No. 9 7.90	No. 9 7.80	*	No. 7 4.60	No. 1 5.00	59.70	47.38	35.00	142.08	78.93
2	P. H. Zipp.........	1898	No. 2 6.37	No. 2 9.20	No. 2 9.30	No. 4 7.04	No. 2 9.20	No. 4 9.30	No. 4 9.00	No. 2 4.55	No. 3 4.80	No. 1 5.00	73.76	54.60	36.33	164.69	91.49

*The study of French during the year 1901-02 was optional, but is now required. Numbers above multiples indicate order of merit in subjects.

ADDRESS delivered by Rear Admiral George W. Melville, Engineer-in-Chief, U. S. Navy, at the Sixteenth Annual Commencement of the Baltimore Polytechnic Institute, held at the Academy of Music, Baltimore, Md., June 16, 1902.

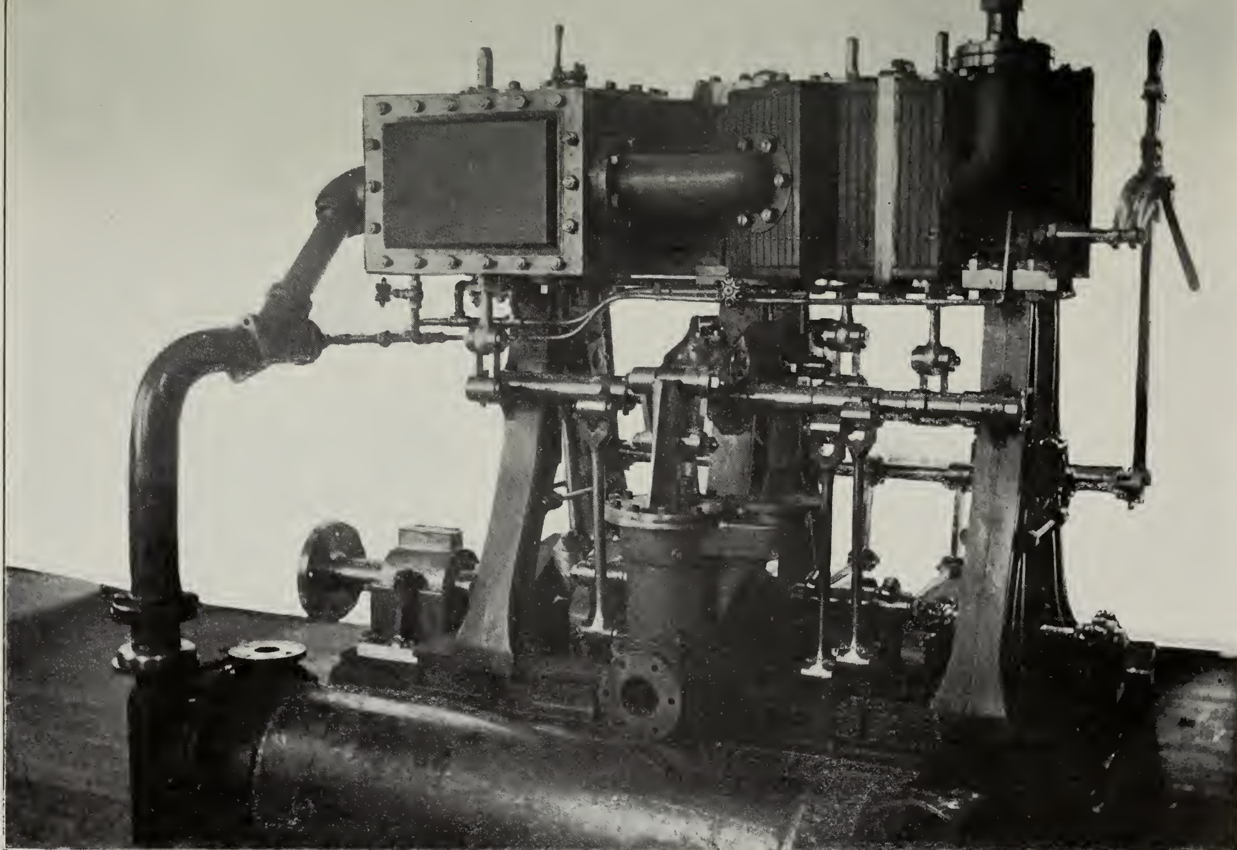
THE DEVELOPMENT OF TECHNICAL EDUCATION A LOGICAL ACCOMPANIMENT OF MODERN EDUCATIONAL METHODS.

As the triumphs of the last century were distinctively of an engineering nature, the attention of the world has been directed to the character and scope of the work of the leading Institutions of Technology, and to the accomplishments of the successful Colleges of Mechanic Arts and Textile Schools. The belief is prevalent that our industrial advance and superiority has been secured in considerable part by reason of the work of the Scientific Institutions. It is because the public is of the opinion that the educational work of the Schools of Technology is of a practical nature that the material prosperity of the several institutions has greatly increased. The number of undergraduates pursuing scientific courses is progressively increasing, and it is not at all improbable that within a short time there will be as many technical as classic schools of learning.

The value of the Colleges of Liberal Arts is as fully recognized now as in years past, but the world believes that there is an educational field which is not covered by their work. The increase in the number and equipment of the scientific institutions, and the work accomplished by the graduates of these schools conclusively shows that, by their existence, industrial results were obtained which could not have been secured otherwise. The events of the last two decades show that a technical education and training makes for better industrial work and secures a greater output of product than was ever obtained before.

In every walk of life where engineering ability can be applied, it is noted that the general supervision of affairs is being entrusted more and more to those who have had a thorough scientific training. Less than fifty years ago nearly every house was designed by its builder—it is now the exception where even a modest dwelling is erected without the supervision of the professional architect. It was not many years ago when it was believed that the superintendence of large industrial plants could only be entrusted to men who had worked their way progressively from the most humble station in the establishment—in the present day, it is not an uncommon thing, to see a graduate, who has been out of a technological institution less than ten years, in absolute control of large manufacturing concerns.

The more carefully the work of a technological institution is studied, the more impressed must one be with the fact that the graduates



TRIPLE EXPANSION ENGINE.

Built by students after design of the Bureau of Steam Engineering, Navy Department.

of such colleges receive an executive as well as a professional training. Carefully prepared statistics show that over half of the scientific graduates drift towards purely executive work. However desirous one may be to become a specialist along technical lines, he must have a general engineering and executive training to fit him for useful work. The engineer who does not possess executive ability seldom gets beyond the drawing or designing rooms. The substantial rewards of the profession go to those who perform executive duties, and this fact is soon appreciated by the undergraduate.

There is no royal road to engineering success. No scientific degree can be secured by attending a course of professional lectures for several collegiate years. Systematic and thorough study is required. It is a matter of record that it is not possible to matriculate in any scientific institution of good standing unless the candidate has graduated from a high school, or has pursued a nearly equivalent course of study. Although it may be difficult to successfully complete a scientific course, the records are convincing that a technical education is of substantial worth, and that it provides a career whose limitations are only bounded by the abilities of the student. Those who possess mechanical ingenuity and engineering talent can certainly look for substantial rewards in pursuing an engineering curriculum.

There are other hindrances to securing an engineering degree. It will be well to bear in mind that the expense connected with securing a scientific degree will undoubtedly average higher than that incurred in getting a classical degree. This is due to several causes. The curriculum of the scientific college requires every undergraduate to pursue a four-year course of study before graduation, while a degree can be secured in some of the law and medical schools after three years of professional study. In pursuing the scientific course, the student is subjected to physical and mental strain, and it will be found that it requires more and better food to keep him up to his work. It may be a matter of surprise that the average cost of maintaining a student at a scientific institution is greater than that incurred in pursuing a course at a College of Liberal Arts, nevertheless it is a fact.

The average student, however, upon graduation from a technological college, is able at once to earn a living. The salary awaiting him may be small, and the opportunities for rapid promotion few, and the fact is soon impressed upon the mind of such young men that failure awaits them unless they buckle down to work. This condition of affairs makes for character and for self-reliance in young men, even if it does occasionally cause temporary discouragement in their professional work.

The industrial resources of this country are so great that it will be absolutely impossible for the technological colleges to send forth

sufficient men to assume the places of leadership that have been opened. The cost of obtaining a scientific education is the bar that will prevent the profession from being overcrowded. Many of the industrial leaders of the future must thus be sought elsewhere than from these colleges. The urgent demands of industry, however, will cause an extension of the work of the scientific schools. It will not be long, therefore, before we shall have proportionately as many technical schools as we shall have classic institutions of learning. There are two factors that will prevent them from increasing very rapidly in number—the time required to pursue such a course of instruction and the financial expense incurred during that long term of probation.

As engineering leaders will be needed, it is the duty of the State to give consideration to the question of training them. In the last century the apprenticeship indenture continued over a long period, and as a result men in all vocations were well trained. It is to be regretted not only that, in the present age, the number of apprentices is progressively decreasing in number, but also that the character of their training is becoming poorer. Here is another cause which reduces the opportunity of the average young man to attain the success and prominence that were within the grasp fifty years ago of every boy of mental vigor and of sound constitution.

It looks as if the State will be compelled to do something in encouraging the training of artisans. The machine is turning out more and better work each day, while it is a matter of common belief that the average machanic is becoming less efficient. This is a matter that not only concerns individuals, but is one that affects the prosperity of the State. It is now the duty of the commonwealth to investigate the question as to the utility of establishing polytechnic institutions and schools of trades. The commercial college is now part of the public school system. It may be essential that we should have a School of Trades. The commercial instinct is developed very early in the boy, for self preservation soon compels him to imbibe some business principles. As technical and scientific attainments can only be developed by systematic and continuous study, the principles of mechanism cannot be acquired without effort and observation.

The City of Baltimore is to be congratulated upon the fact that public spirited men of the municipality have had the zeal and energy to insist that a school should be established where it will be possible, at the public expense, for a boy to receive a training that will develop his latent engineering and scientific abilities. In arousing these talents the character of the student will also be developed.

It is because such schools as this are in successful operation, and because the work of this institution opens up a new field, that there is a growing belief among educators, that the public schools should under-

take the work of making the hand more useful in securing a livelihood. Experience shows that, in training the hand, the eye becomes more observant and the ear becomes more sensitive.

Character is not formed until the individual begins to think for himself. The public school is therefore a greater factor in moulding character than is appreciated by most people. In the home of the artisan and the laborer, so much of the time of the mother is taken up in the care of the children of tender years and in carrying on the duties of the household, that it is exceedingly probable that often the teachers in the public schools are as important factors in moulding character as are the parents. The training of the mind should not, however, be the single purpose of educators. The province of the institution should be to help mould character; to train the hand to practical work; to make the eye observant to the wonders and work of nature, and to make the ear quick to note everything that w ll broaden the intellect. It is because the friends of this Institute believe that there is a certainty of this school's doing good work in bringing about this result, that I believe it has been established.

There is hardly a city in this country where some manual training is not given the pupils of the public schools. So little time is devoted to this purpose that in some cases as much evil as good has resulted from its introduction. If only one period of two hours each week is given to manual training, then little good can be accomplished, since such a period is too short to permit the average child to become skilled in the use of any mechanical appliance. The believers in manual training should not permit such a state of affairs to continue. Where so little time is devoted to the work, it will be found that the average scholar receives but little benefit, and the practical result is to interfere with the regular work and discipline of the school. The value of manual training will never be determined until the scholar takes as much interest in the workshop as he does in the class-room.

There is not an educator who does not realize that it takes years of study before the guiding principles of mathematics can be instilled into the mind of the average scholar. In fact, it will be found that in many cities some branch of mathematics is taught from the day the child enters the first primary grade until he finishes the senior year of the high school course. It should be remembered that mathematics is an exact science. There is an incentive to acquiring its principles, by reason of the fact that both pleasure and profit are secured in possessing even an elementary knowledge of the several branches. The study of the mechanic arts must be conducted in the same systematic and persistent way in which mathematics is taught. The principles underlying the study of technical subjects can only be mastered by time and application, and failure is sure to result if the subject is to be regarded as only a healthy diversion.

Once let the scholar conceive a notion that the time devoted to manual training is a period of recreation or pleasure, and it is certain that from thenceforth the work will neither interest him nor be of substantial value. The importance of the study will increase in proportion to the greater interest in which it is held by Trustees and Faculty. The student who enters upon such a course of instruction will not be impressed with the value of the work until the community at large holds it in esteem, and until he is convinced that it requires study and reflection to do good service at the lathe as well as at the blackboard. Another purpose of such a school should be to develop the mechanical talents to such an extent as to impress upon the scholar himself the particular occupation or vocation wherein he can hope to have the best chance of doing good work in the future.

There is much in a name. The Board of School Commissioners are to be congratulated in selecting for this school a name which, in itself, is a comprehensive statement of the general course of study pursued, as well as a prospectus of the plans and purposes of the founders of the institution.

It may not be the purpose of this school to teach trades. You can't carry on this work, however, without convincing many thoughtful scholars that they should start life in the machine shop or shipyard, rather than behind a counter or in an office. Your experience may prove that a school of trades is absolutely necessary to round up the work of a public school system. The Polytechnic Institute, however, should carry on work of a more practical nature than that given at a technological college, while it should teach more theory than could be imparted by the School of Trades.

The value of a School of Trades appeals very strongly to me. After a boy is twelve years of age he ought to do some hard work if for no other reason than for his physical development. If we could establish such a school, we could insist on longer hours. It would be found that as the muscles were hardened, chests expanded, and bodies straightened, the brain would act more quickly. The scholars pursuing such a course would not be far behind their playmates of other schools either in English studies or mathematics, for with physical development would come mental growth. The students of the School of Trades would more than hold their own in all outdoor sports. The boy who could swing a sledge with precision and strength, would have little to fear in butting up against the youth whose physical development had been entirely secured on the athletic field. In acquiring practically every one of the manual trades, one brings into play nearly every muscle of the human body. If the boy could be impressed with the fact that he is being helped to become an athlete by engaging in such work, it is probable that he would take more kindly to such education.

It also augurs well for the future of this school that "In order to secure the continuance of local interest in, and oversight of the Institution, a Board of Visitors has been appointed, whose province it shall be to make recommendations and suggestions whereby the work of the School could be made more efficient and brought in closer touch and knowledge of the general community." I believe in people visiting the public schools, and that such visitors should carefully note the character of the work that is being done. The best friends of the public school system are those who, from personal observation, know something of the difficulties and disappointments that beset teachers and scholars. The sincere criticism of such visitors is particularly desired by trustees and teachers. Particularly welcome are suggestions which come from a Board of Visitors, for it is understood that such recommendations are made after careful deliberation and reflection.

The successful work accomplished at West Point and Annapolis can in part be ascribed to the interest taken in those institutions by the Boards of Visitors. There are always some members of these Boards who consider it their duty to study the methods of the schools, and to find out whether or not their work is progressively improving or diminishing. The searching inquiries made by thoughtful members of the Board compel the faculties of both West Point and Annapolis to keep abreast of the times. The War and Navy Departments, as well as the Naval and Military Committees of the Congress, give particular attention to the annual reports of these Boards. As the members of the several Boards of Visitors serve without pay, and often accept the duty at great personal inconvenience, it is recognized by the Secretaries of War and Navy that the Boards' recommendation should be given great weight.

Progressive development and success will be secured if the Baltimore Polytechnic Institute continues to receive the oversight of a Board of Visitors who consider it an honor to accept such an oppointment. In the conduct of a great industrial enterprise, it is often the the case that some stockholder of the corporation, who is not a salaried officer, will often be a leading factor in deciding important questions, for it is realized that such persons are not wedded to particular beliefs and methods, and are therefore free to give unbiased opinions upon matters where sound judgment is required. I believe that it will be well for the Board of Visitors to this institution to submit an annual report of their work and observations. If their recommendations are made a matter of record, it is not likely that they will be overlooked by the School Commissioners.

The Board of School Commissioners have undoubtedly found out that considerable expense is incurred in maintaining this institution. It should be remembered that you are practically doing pioneer work,

and therefore the expense per capita of each student is now greater than it will be in the future. It required some moral courage upon the part of progressive and public-spirited citizens to attempt to ingraft manual training upon the city's school system. There are people who regard such a change as a reflection upon existing arrangements. Men who had the courage to commence such a great work are not likely to be dismayed because unexpected impediments are met. When the crowd is surging one way it is not easy to get out of the drift. The good accomplished by the public schools during the last century is convincing proof to the majority that they are fully adaptable to existing needs. May it not be the case, however, that our new conditions require new methods, and that the technical school is a concomitant of modern industrial progress?

The direct benefits that have ensued since the organization of this school justify the continuance of the institution, but who can tell of the indirect good that has already been accomplished? The existence of this institution is a practical declaration upon the part of the city of Baltimore, that the municipality proposes to take upon itself, at least in part, the duty of securing trained artisans for the future. It is certain that those who would discourage the training of apprentices must regard this school as a warning that the community frowns upon such an effort. It is as great an evil to attempt to secure a corner on skilled labor as it is to secure a corner on breadstuffs. It is the poor man in both cases who suffers most. It is not the capitalist or the professional man who is most desirous of apprenticing his son to a master-builder—it is the artisan or the unskilled laborer who is most anxious to have his son learn a trade. If the effort to prevent boys of character from learning trades continues, then the city should hold this school up as a warning, for it is within the power of the municipality so to extend the scope and work of this institution, that not only a common school education, but also a trade could be acquired at the city's expense.

The existence of this institution is also an answer to those critics who contend that the duties of the Board of School Commissioners are of a perfunctory nature, and that the curriculum of the public schools is not being progressively adapted to the demands of the present. This city ought to be wealthy enough to establish a second school, for I believe that every institution of an educational nature should enter into earnest and healthy rivalry with another school of like description. Competition in educational methods is as beneficial as competition in trades and business, and this school must be benefited by having its work brought into competition with another institution working in the same field.

This institution must also have an influence for good upon the other schools of the city. Those particularly interested in the work of high

schools must appreciate the fact that their work is being compared with the results secured here. In acting as a spur and an incentive to the schools of other systems, who can determine the influence for good of your special work in the line of technical training?

In measuring the results secured from these schools of Mechanic Arts, many persons estimate the value of the work done by the accomplishments of the first year. As a matter of fact, the apparent results secured the first year will amount to very little, since it takes time and patience to develop a mechanical mind. In the construction of a ship much time and labor is spent before the keel is laid. The naval architect and marine engineer believe that in getting out the preliminary designs, exceeding care and study should be taken. Several years ago it was asserted by a dean of a law school that the majority of his students did not appear to have any comprehension of the principles underlying the study of law until near the close of the required professional course. In other words, it takes time to develop every professional mind. In the accomplishment of every undertaking, much preliminary work is done that may not be apparent to the looker-on. The work of a scientific school should not be judged by the results accomplished by the younger students. Only the preliminary work of training the mechanical mind can be done the first year, and practical results should not be looked for until later.

In the operation of blasting channels, months are often required in the placing of explosives. It may only require a fraction of a second to produce the detonation and subsequent explosion. It will likewise be found in mechanical training that substantial results are not easily and quickly obtained. The technical student acquires but little more than a knowledge of the use of hand tools during the first years of manual instruction. The second year he commences to grasp a knowledge of the various mechanical movements and of the method of combining these movements. The third year brings a maturing of the mechanical mind, and then comes the ability to operate and understand the scope of the machine tool. It is the fourth year's study which makes it possible for the student to put his scientific training to practical purposes, and which fits him in a great part to become a bread-winner.

It is as essential that the scientific course of education should extend over a term of years as that a course of study in the classics should continue for a considerable time. There will not only be a waste of public funds, but there will be disappointment and humiliation if it is attempted to give manual training for a short period. Particularly will the student be wronged if the course is too short, since his training will have unfitted him for purely literary work.

You want to guard against making the work any easier in technical schools than it is in other institutions of learning. In some cases the

notion has been conceived that those entering the technical high schools need not work outside of school hours. This opinion should be eradicated, for surely if the scholars are to work three hours of the six at light manual exercises, they should be required to do one hour's studying each day outside of the section or class-room.

Many people believe that the scholar is given too much work both in the public schools and at college. If he is not given too much work, it is exceedingly probable that he is given instruction in too many branches. It is the effort to master the principles of a half dozen subjects that are not allied to each other that causes most scholars to break down under the load. In arranging, therefore, the most desirable technical curriculum, you can well afford to eliminate subjects that should only be considered by the scientists or advanced students. There need be little fear that any of the scholars will have too few studies—they are all likely to have too many.

In technical training the central idea should be to give every graduate a fair knowledge of mathematics and physics, an excellent course in grammar and composition, and thorough personal instruction in technical branches. The students pursuing a technical course should be made to understand the necessity and importance of being able to give a thorough description of a mechanical appliance. It is possible for a man to be able to work out all the calculations necessary in designing a machine. He may also have the ability to make working drawings of the appliance, but if it is not within his power to draw up specifications that are explicit and complete, he will be a worker rather than a leader in industrial affairs. Placing this high estimate upon the knowledge of good English, I would have this course so thorough, that the scholar would be compelled to devote some time outside of school hours in training himself to write as well as he could talk.

The purely technical course should commence with instruction in wood work, for every mechanic and engineer should know the principles of carpentry. Practically every worker in brick, stone, and iron ought to know how to put up scaffolding, and this is but one of other illustrations that could be given showing than an elementary knowledge of bench work in wood is absolutely essential to the artisan and the engineer. After receiving a course of instruction in carpentry, the student should be compelled to specialize when commencing to work in iron. It is hardly possible for any one to become proficient in more than one metal trade. The average student will find all the employment that he needs either in the foundry, forge, or machine shop, particularly if, while doing this work, he is called upon to take lessons in mechanical drawing. The acquisition of modern languages should ordinarily not be attempted in a technical school—these studies ought either to be taken up before matriculation, or else postponed until after

graduation. It can probably be stated without contradiction that every technical work of any practical value has been translated into English.

In this industrial age, when the engineer is often called upon at short notice to proceed to foreign countries, a knowledge of modern languages is essential to every technical expert. If modern languages, however, have not been acquired before the student enters a technical school, then their study should be postponed until after the close of the collegiate course. I believe that experience shows that the best time to acquire a knowledge of modern languages is either in early years or after a person has reached an age when, from observation, he can estimate their value. The experience at Annapolis and West Point ought to be conclusive evidence as to the difficulty of students acquiring modern languages at a time when they are engaged in many practical and theoretical studies directly bearing upon their future work.

Those who desire to succeed in technical work should also be made to understand the necessity for being exact and thorough. It will not do in engineering works to guess at results. When an engine stops, the particular impairment must be overcome, else the shaft will not revolve. A bridge must be strong enough to sustain safely the weight of a moving train, otherwise it cannot be used. If a rifled gun will not withstand the shock of its explosive, more injury may be done to friends than to enemies. Your work must be thorough and accurate because it is always open to inspection of the community at large. This is not the case with members of other professions—their failures and weaknesses are not at all times evident to their fellow citizens.

The technical man must be a loyal one. He must not only serve faithfully his employers, but he must be loyal to the community and to himself. Serious injury is likely to befall innocent persons if the engineer lacks either technical skill or moral courage. Particularly in Dynamical Engineering must the material and workmanship be of the highest character. That man is most loyal to employer and to himself who will not permit either inferior work or material to enter into any construction for which he is responsible. Loyalty is but another word for honesty and integrity. Character is no less important than efficiency, and the technical man who lacks either of these requisites had better seek a new calling.

Be grateful and appreciative of every person and of every influence that has helped you to succeed. If prosperity comes to you, remember among other influences this institution, and those who are responsible for its organization and operation. Every man who achieves success owes it to himself to do something for his family and for the friends who have helped him to rise. That man is not far from the right track who regards gratitude as the cardinal virtue, and who feels

that all his obligations have not been repaid until he has made some return to every person who has been an element in giving him a career.

Be proud of your chosen work. If the vocation that you have chosen does not command your pride and enthusiasm, then seek a career in another direction. The man that is ashamed of his work or his family is to be pitied. It is every one's duty to elevate his family and his calling, and the best way of doing this is to make no excuses either for one's duty or for one's surroundings.

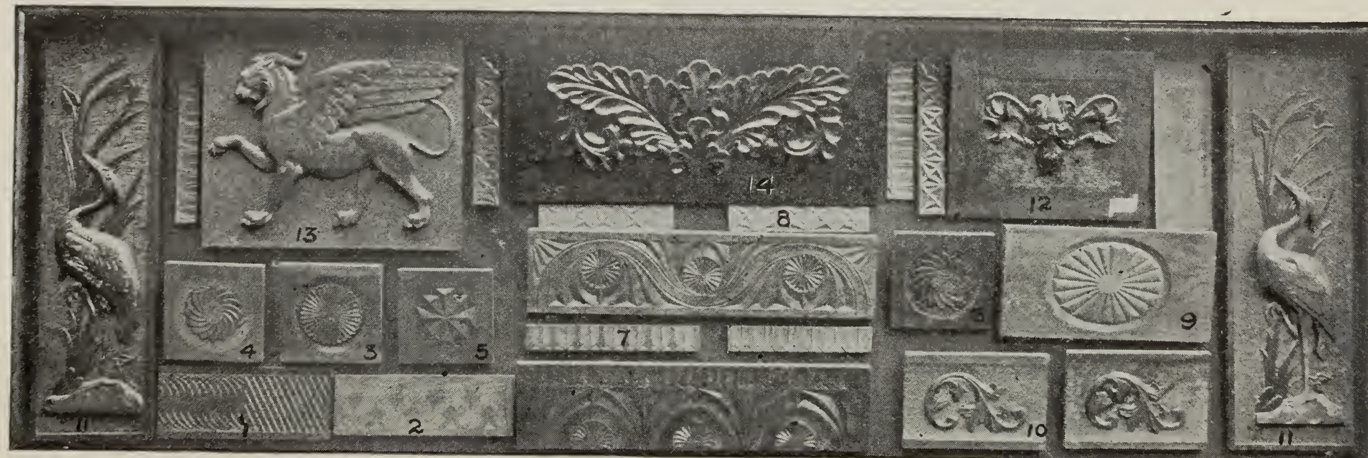
There are times when you should drop your work and study yourself. The serious side of life should occasionally be thought of. There are periods when one cannot escape from being his brother's keeper, for one's whole duty is not to help himself alone. The more persons you can help and the more good you can do while advancing in prosperity, the more successful will be your life's work and the more useful you will be to the community.

In conclusion, I desire to tell of the interest I have in all institutions of this character. They will surely grow in number, and the successful continuance of the public school system may be dependent upon the development of this work. Discouragement and disappointment will have to be endured before success can be assured, but I want both faculty and Commissioners to understand that if in any way I can aid you, either by personal work or by official duty, my services are at your command.

This Polytechnic Institute should not only receive substantial financial support from the city, but it is worthy of the personal interest of all who believe that with new conditions must come even new educational methods. It is not technical training which is on trial in this school, for instruction of that character is essential to the supremacy and even to the maintenance of our industrial progress. It is rather the adaptability of the public school system to extension in the direction of technical training that is being tested.

It is not the people of this city alone who are interested in this experiment. In the establishment of this school, you have done advance work for others. I, therefore, congratulate the Commissioners upon their wisdom and foresight in projecting this development, and upon their moral courage in carrying out their purpose in the face of the obstacles which they have encountered. The Principal and the members of the Faculty are also deserving of commendation for the character and scope of the work which has been executed.

I extend to the graduates my sincere congratulations upon their good fortune in being permitted to enjoy the educational and technical advantages that have been presented by this institution. With these congratulations are extended good wishes for success in connection with everything relating to the school.



WOOD CARVING,

SOME OF THE EXAMINATION PAPERS SET IN JUNE, 1902.

STEAM ENGINEERING.

Fourth Year Class, May 29, 1902.

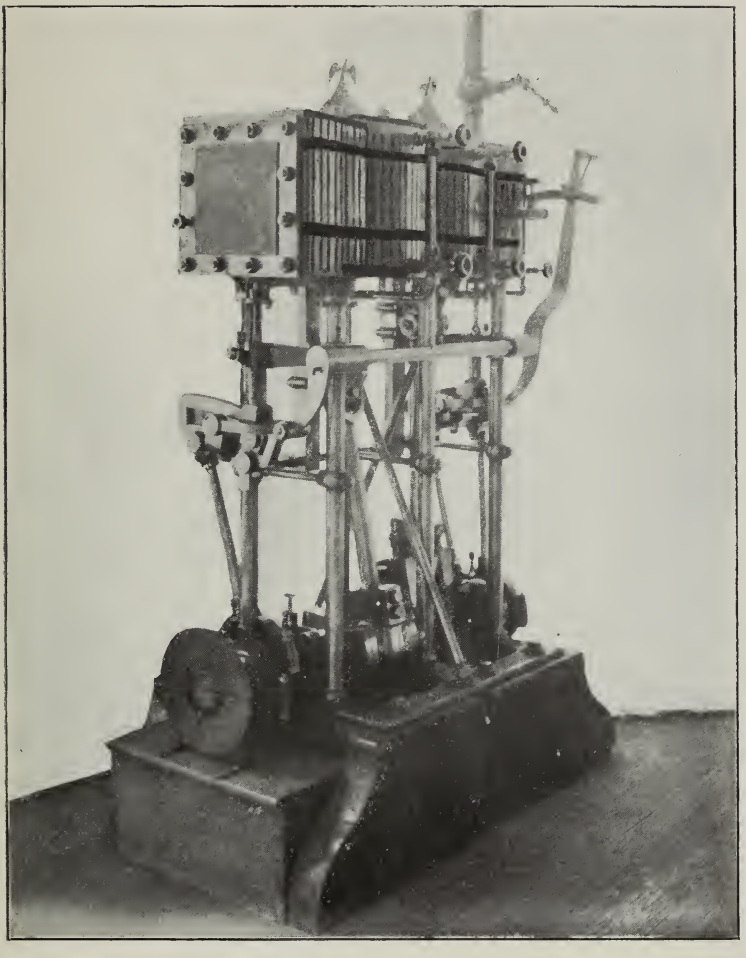
1. Deduce the general expression for the value of the mean pressure of any gas working in a cylinder, the gas expanding according to any law. When the expansion is according to Boyle's Law, what is then the expression for the mean pressure?

2. Diameter of cylinder 9″, stroke 10″, clearance 7%. Initial absolute pressure 95 lbs., back pressure 17 lbs., cut-off 28%, clearance 7%. Release takes place at 90% of stroke, and the exhaust closes after 70% of the return stroke is completed. The expansion and compression following Boyle's Law, you are required to construct the expected indicator diagram, and to find the terminal pressure p_2, the terminal pressure of compression p_c, and the mean effective pressure p_e. Scale of stroke ½, and of pressure 40. If the engine is to make 365 revolutions per min., what I. H. P. may be expected?

3. Upon what does the diameter of the cylinder of an engine and the mean pressure to be used depend? What are the principal causes that make the mean pressure obtained less than that theoretically due to the initial pressure and ratio of expansion? What are the mean pressure factors used for modern stationary engines? for compound engines? for triple-expansion marine engines?

4. Required the dimensions of a two-cylinder compound engine to develop 1,500 I. H. P. Piston speed 850 feet per min., absolute initial pressure 110 lbs., absolute back pressure 3 lbs., cut-off in H. P. cylinder ½ stroke, H. P. clearance 10%, and that of L. P. 9%. Ratio of cylinder 3.75. Use a mean-pressure factor of .7, and find Naperian logs. by multiplying common logs. by 2.303. After finding the cylinder diameters you will select a suitable stroke, and then find the number of revolutions the engine must make per min. Find also at what part of the stroke the steam must be cut-off in L. P. cylinder.

5. Into what classes are steam boilers grouped? Give a general description of a Scotch boiler and of a sectional boiler. What advantages are claimed for the sectional boiler? Mention some disadvantages. In the design of a shell boiler what values do good practice assign to the following ratios, viz.: $\frac{\text{I. H. P}}{\text{Grate Surface}}$, $\frac{\text{Grate Surface,}}{\text{Heating Surface}}$; what is the relation between the steam space and the I. H. P.? What form of furnace is universally used in shell boilers?



COMPOUND ENGINE.

Built by students after design of the Bureau of Steam Engineering, Navy Department.

6. The exterior diameters of the tops of the corrugations of a furnace flue are 39″ and at the bottom 36″. The pressure to be carried is 200 lbs. per sq. in. What thickness of flue should be used?

Find the thickness of plates required for a boiler shell to be worked at a pressure of 160 lbs. per square inch. Diameter of shell, 8 ft.; efficiency of riveted joint, 89%; stress in plates, 5 tons per square inch.

7. Length of connecting rod 40″, stroke 20″, travel of valve 4″, lead angle at top 9°, mean cut-off 70%, and release top and bottom 1-10 from end.

Construct a Zeuner diagram and find the steam lap, the exhaust lap, the steam opening, the exhaust opening, the lead, and the angular advance of the eccentric.

Scale of crank diagram, ¼, and of valve diagram, full size.

MECHANICS.

Fourth Year Class, May 26, 1902.

1. A beam 20 ft. long, weighing 25 lbs. per lineal foot, is supported at the ends. Where should a weight of 600 lbs. be placed in order that the pressure on the right support should be ⅔ that on the left support?

2. BCDO is a flat plate, right angled at C, and having the following dimensions: BC = 18″, CD = 15″, DO = 12.5″, and the perpendicular from O on BC measures 18.5″. Construct the figure to a scale of 1.5 inches to the foot, and locate graphically the centre of gravity of the figure.

3. Find the centre of gravity of a trapezoid.

4. An equilateral triangle rests on a square, and the base of the triangle is equal to a side of the square; find the centre of gravity of the figure thus formed.

5. The length of the power arm is 15″; find the distance between two consecutive threads in order that the mechanical advantage may be 30.

6. If the force required to draw a train of cars on a level railroad be $\frac{1}{200}$th part of the load, find the force required to draw it up a grade of 1 in 56.

7. A body weighing 6 lbs. is placed on a smooth plane which is inclined at 30° to the horizon; find the two directions in which a force equal to the weight of the body may act to produce equilibrium. Also find the pressure on the plane in each case.

8. A uniform beam has one end resting against a rough vertical wall, and the other end against a rough horizontal plane. The co-efficient of friction between the beam and wall is ⅔, and between the

beam and horizontal plane it is 3/8. Find the inclination of the beam to the horizon when it is about to slip.

9. A crane has a vertical post 9 ft. high and a boom 18 ft. long. The angle between the boom and post is 45°. Find by calculation the tension on the tie and thrust on the boom when a load of 6 tons is suspended from the extremity of the boom. Prove the accuracy of your results by solving the question graphically by means of the triangle of forces: what is the pull on the top of the post?

10. A boom AO is supported by a pin in a vertical wall OB at O, and at the end A by a guy AS running to the wall and making an angle with it of 30°. At the end of the boom is suspended a weight of 500 lbs. The weight of the boom is 300 lbs., the distance SO is 10 ft., and the length of the guy is 20 ft. Find the tension on the guy, and the portions of the thrust of the boom sustained by the pin and by the wall.

MECHANICS OF MATERIALS.

Fourth Year Class, June 4, 1902.

1. Define stress. What kinds of direct stresses are produced in bodies by exterior forces? Define elastic limit, factor of safety, resilience. A bar 2 inches in diameter ruptures under a tension of 173,000 lbs : what is its ultimate strength?

2. To what character of loads is the piston of a steam engine subjected? The cylinder of an engine is 9 inches in diameter, and the steam pressure per square inch 100 lbs. If the piston rod is to be of steel whose ultimate strength is 70,000 lbs. per square inch, what should be its diameter, allowing the proper factor of safety?

3. Illustrate graphically how a bending moment is produced in a bar. To what is the bending moment at any section of a beam equal? A simple beam 12 feet between supports has a load of 200 lbs. at 4 feet from the left end and a load of 475 lbs. at 2 feet from the right end: find the bending moment at a section 5 feet from the right end.

4. Compute the moment of inertia of a T section whose depth is 4 inches, width of flange 3.5 inches, thickness of stem 3/8 inch, and thickness of flange 3/8 inch. Compute also the modulus of the section.

5. Find the polar moment of inertia and the radius of gyration of a circle treated as a thin lamina.

6. When does a sheer stress exist in a beam? To what is the sheer at any section of a beam equal? Construct the sheer and bending moment diagrams of the beam of Question 3, and determine therefrom the bending moment at the section 5 feet from the right end.

7. The flat top of the combustion chamber of a boiler is to be braced by girder stays. The area supported by each girder is 28'' x 8'', and the pressure per square inch 200 lbs. Each stay is to have three bolts

symmetrically placed. The girders are to be arranged in pairs, and, assuming the width of each to be ⅞″, you are required to find their depth, taking the working stress as 8,500 lbs. per square inch.

8. Find the diametral dimensions of a hollow steel shaft to transmit 8,000 I. H. P. at 115 revolutions per minute, the stress on the exterior circumference not to exceed 8,000 lbs. per square inch, and the interior diameter to be 98% of one-half the exterior diameter. Find also the diameter of a solid shaft to transmit the same power under the same conditions. Compare the weights of the shafts, and prove that they are equal in strength.

9. In a rolled steel beam, symmetrical about the neutral axis, the moment of inertia of the section is 72 inch units. The beam is 8 inches deep, and is laid across an opening of 10 feet, and carries a distributed load of 9 tons. Find the maximum fibre stress, also the central deflection, taking E at 13,000 tons per square inch.

MATERIALS OF ENGINEERING.

Fourth Year Class, May 20, 1902.

1. Mention some of the metals used by the engineer in forming alloys. Describe the properties of copper, and state some of the uses of this metal. Name the metals and, approximately, their proportions used in forming the alloys known as common yellow brass, gun metal, navy composition, steam metal, manganese bronze, phosphor bronze, spelter, and babbitt metal.

2. In the classification of iron and steel, mention the metals known as malleable, semi-malleable and non-malleable.

3. By what process is cast-iron reduced from the ore? How is the quality of cast-iron affected by the various methods and different fuels employed in its reduction? How is pig-iron usually graded? Name some of the brands of pig-iron. From what source does cast-iron absorb much carbon? In what two forms does carbon unite with cast-iron? What is the difference in the character of cast-iron containing a high percentage of graphitic carbon and that containing a high percentage of combined carbon? How is the fluidity of cast-iron affected by the amount of carbon it contains?

4. Describe the effect of slow cooling and of sudden cooling on cast-iron when in the mould. How are the color and appearance of the fracture of cast-iron affected by the amount of graphitic carbon present? Can cast-iron be united to itself, or to wrought-iron, or to steel? Describe how a large casting may be mended. How can cast-iron be made partly malleable? Where are malleable iron castings used in engineering work? Describe the process of inspecting iron castings. Name the different physical tests for cast-iron. Sketch and show dimensions of the conventional form of test-piece used for the tensile, transverse and compressional tests of cast-iron.

5. Name the process by which cast-iron is converted into wrought-iron. When the conversion is complete, by what name are the puddled balls known? After being compressed under the steam hammer and passed through the rolls of a mill, how are the bars designated? Name the element which is nearly eliminated from the iron by the puddling process. Explain how slag affects the quality of wrought-iron. What effect on wrought-iron has an excess of phosphorus and of sulphur? What are the special properties of wrought-iron? Name some of the brands of wrought-iron. Name the different physical tests for wrought-iron, and make a sketch showing the form and dimensions of the piece used for the tensile test.

6. On what do the properties of steel partly depend? What impurities, other than carbon, are contained in steel? When the percentage of these impurities is high, what effect does each have on the steel? Explain the method of making high-grade steel. By what process is mild, or structural, steel produced? In the production of steel for engineering purposes, which of the two processes is preferable. and for what reasons? Explain what is meant by the acid and by the basic processes. Define spiegeleisen and ferro-manganese. Define semi-steel, nickel-steel, chrome-steel and tungsten-steel. How are the strength and ductility of steel affected by an increase of carbon in its composition? Describe the different physical tests for structural steel. Make a sketch showing the forms and dimensions of the conventional test-pieces used for testing steel for boiler plates, for shafts, and for piston-rods. What tensile strength and elongation are required of steel used for plates that are to be flanged, and for boiler rivets, shell plates, steel castings, shafting and piston-rods?

DIFFERENTIAL CALCULUS.

Fourth Year Class, February 21, 1902.

Questions 1 or 2, 3, 6 or 7, 9, and one other are required.

1. (a) If $f(x) = 2x\sqrt{1 - x^2}$, show that $f(\sin\frac{x}{2}) = \sin x$.

(b) If $f(x) = \log\frac{1 - x}{1 + x}$, show that $f(x) + f(y) = f(\frac{x + y}{1 + xy})$.

2. (a) Give the definition of a derivative. (b) Of what steps does the process of differentiating $f(x)$ consist?

3. Derive the formula for $\frac{d}{dx}(\sin u)$.

4. Develop $\tan x$ in a power series of x.

5. Evaluate (a) $\frac{e^x - e^{-x}}{\sin x}$ when $x = 0$; (b) $\frac{x^4 - 2x^3 + 2x - 1}{x^6 - 15x^2 + 24x - 10}$ when $x = 1$.

6. The diameter of a cylindrical tree is d. Find the strongest beam that may be cut from it, assuming that the strength is proportional to the breadth multiplied by the square of the thickness.

7. A rectangular court is to be built so as to contain a given area; a wall already constructed is available for one of the sides. Find its dimensions so that the least material may be required.

8. Show that the exponential curve $y = ae^{\frac{x}{c}}$ has a constant subtangent.

9. Given $y^2 = 4ax$; find $\frac{ds}{dx}$ and $\frac{dV}{dx}$.

10. Find the radius of curvature: (a) in the catenary $y = \frac{c}{2}(e^{\frac{x}{c}} + e^{-\frac{x}{c}})$;

(b) in the exponential curve $y = ae^{\frac{x}{c}}$.

INTEGRAL CALCULUS.

Fourth Year Class, June 2, 1902.

1. Prove (a) $\int_a^b f(x)\,dx = -\int_b^a f(x)\,dx$;

(b) $\int_a^b f(x)\,dx = \int_a^c f(x)\,dx + \int_c^b f(x)\,dx$.

2. Find the curve for which the length of the subnormal is proportional to the square of the length of the abscissa. Determine the curve so that it shall pass through the origin and point (3, 4).

3. Write twenty fundamental formulæ of integration.

4. Derive the formulae $\int cosec\, u du$, and $\int \frac{du}{u^2 - a^2}$.

5. Find $\int \frac{dx}{x^2\sqrt{a^2 - x^2}}$, and $\int \sqrt{a^2 - x^2}\,dx$.

6. Integrate (a) $\sin y \sec^2 x dx + \tan x \cos y dy$;

(b) $cosec\, x \cos y dy - cosec\, x \cot x \sin y dx$.

7. Find the volume of the prolate spheroid generated by the revolution of the ellipse about the x-axis.

8. Find $\int sin^{\frac{2}{3}} x \cos^5 dx$, and $\int \frac{\sin^3 x}{\cos^7 x}\,dx$.

9. Find $\int_2^3 \int_1^2 \int_2^5 xy^2 dz\, dy\, dx$, and $\int_0^{\pi} \int_0^{a(1+\cos x)} r^2 \sin x\, dx\, dr$.

10. Find the volume of the elliptic paraboloid $2x = \frac{y^2}{b} + \frac{z^2}{c}$ cut off by the plane $x = a$.

EXAMINATION IN ELECTRICITY.

Fourth Year Class, June 6, 1902.

1. Sate cause of trouble and temporary remedies, if any, when generator exhibits following defects:

(*a*) Heavy sparking, sparks appearing as a band of light around commutator; (*b*) Fall in E. M. F., heating, sparking and extra pull on engine; (*c*) Sparking and low potential, but no extra pull or heat except at commutator, and that only of such intensity as to be attributed to heat produced by sparks. (*d*) The E. M. F. only a few volts and the generator refuses to build up.

2. Explain why a regulator must be used on a series motor operated on a constant current circuit? Also show how same method of winding may be used on constant potential circuit and be almost self-governing.

3. What number (B & S) wire should be used as a feeder for supplying three buildings situated at 300, 350 and 450 feet, respectively, from generator and having 90, 75 and 100 lamps, respectively, each lamp requiring 60 watts, E. M. F. 110, and drop being 4% of lamp voltage? Also give sizes of mains to each building.

4. State clearly, using diagram, the effect of increasing the load of a transformer.

5. Explain the use of an equalizer in the operation of compound wound generators. Give directions for throwing in an additional generator, giving reasons for each step.

6. A line 15 miles long shows a ground. Give diagram for locating distance of ground from testing station by loop method. Assuming the ground is 5 miles distant, insert in diagram readings to correspond.

7. Show connections for finding insulation resistance of lighting circuit, both for insulation between conductors, and between conductors and ground.

On a 125 volt circuit, what would be the readings if insulation resistance between conductors was 100000 ohms and between each conductor and ground 150000 ohms? Voltmeter resistance 20000 ohms.

8. Outline principal connections made by controller of electric car. Why is rail bonding necessary? How is the shock upon the gearing, produced by the starting of the motor, partially prevented?

9. Give sketch of connections of simple telephone line with two stations. Give outline of various operations in and out of exchange (central energy) when call is made for connection with another subscriber.

10. Describe the controller of the Brush arc-light generator. Explain method of *detecting* ground in a high potential *alternating* circuit.

EXAMINATION IN CHEMISTRY.

Fourth Year Class, May 12, 1902.

1. Describe method of separating bases into seven classes as described in Eliot and Storer's Manual, giving reagents for each class.

2. How are carbonates distinguished from other effervescing compounds? How are sulphates distinguished from other substances precipitated by barium chloride?

3. Describe method of making test for quantity of silver in solution by gravimetric method.

4. Write formulae indicating reactions in treatment of mercuric chloride with sulphuretted hydrogen, dissolving precipitate in aqua regia, and depositing metallic mercury by copper.

5. Make calculations for amount of salt to be dissolved in 1,000 c. c. of water to precipitate 5 centigrams of silver to 1 cu. cm. of solution. How much silver nitrate would be in a solution which requires 40 c. c. of solution to precipitate it? How do you know when precipitation has ceased? The combining weights of Ag, N, O, Na and Cl are respectively 107, 14, 16, 23 and 35.

6. Give outline of test for per cent. of carbon in steel. State object of various compounds in absorbing train.

7. An analysis in the laboratory of a given solution. (This question has the value of 30% of the entire examination.)

EXAMINATION IN STEAM ENGINEERING.

Third Year Class, May 26, 1902.

1. Make six sketches showing the action of the slide valve in distributing steam in the cylinder during a stroke of the piston, enumerating the events of the stroke.

2. Define lap and lead. For what purposes are lap and lead given to a valve? What types of engines require link motions? Why is the Stephenson link particularly well adapted to locomotives? Explain in general terms the action of a shaft governor and shifting eccentric in automatically cutting off the steam.

3. Length of the connecting rod 5 feet, stroke 30 inches. Find the position of the piston, measured from each end of the stroke, when the crank makes an angle of 150° with the head dead point.

4. The piston is at the head end of the stroke. Angular advance of the eccentric, 50°. Length of eccentric rod, 50 inches. Diameter of the shaft, 9 inches, and of the eccentric disc, 15 inches. Thickness of strap, 1.25 inches. Thickness of strap lugs, 1.25 inches, and their length, 2 inches. Width of rod at strap end, 4.5 inches, and at valve end, 2.5 inches. Travel of the valve, 4 inches. Diameter of eye at valve end of rod, 2 inches. Make sketch to a scale of 1.5 inches to the foot.

State briefly the advantages claimed for the stage expansion engines.

5. What does the number on the spring of an indicator indicate? From a given indicator diagram how would you tell whether it is from a condensing or a non-condensing engine? Explain explicitly that the expression $\frac{pLaN}{33\,000}$ gives the horse-power of an engine,

6. The triple-expansion engines of the U. S. S. Albany are 31″, 46″, 70″ x 30″. Clearance of the H. P. cylinder 18% and of the L. P. cylinder 15%. On her trial trip the H. P. cut-off was 21.8″ from commencement, and the initial absolute steam pressure, 165 7 lbs. Find the total ratio of expansion and the terminal pressure in the L. P. cylinder. Prove the accuracy of your results by showing that the calculated volume of steam in the L. P. cylinder and clearance at the end of the stroke is just equal to the volume of the L. P. cylinder and its clearance. The specific volume of steam at 165.7 lbs. is 2.7319 cubic feet, and the specific volume of the steam at the L. P. terminal pressure may be found by the formula $pv^{\frac{17}{16}} = 482$.

TRIGONOMETRY.

Third Year Class, June 6, 1902.

1. (*a*) Derive the functions of $(180° + x)$ in terms of those of x:
   (*b*) Derive the functions of $(270° - y)$ in terms of those of y.
2. (*a*) $\sin(x - y) = ?$ (*b*) $\cos(x - y) = ?$
3. Find the functions of half an angle.
4. Prove the law of tangents.
5. The two diagonals of a parallelogram are 5 and 6, and the angle they form is 49° 18′. Find the sides.
6. If the sides of a triangle are 4, 3, and 6, find the sine of the angle opposite the side 6.
7. In the system of logarithms whose base is 20 find the logarithm of $\frac{1}{10}$.
8. State Napier's Rules. Write the formulae relating to right spherical triangles.
9. Prove $\tan^2\left(45° - \frac{A}{2}\right) = \tan\frac{c - a}{2} \cot\frac{c + a}{2}$.
10. Given $a = 50°$, $b = 36° 54' 50''$, $C = 90°$; find c, A, and B.

ANALYTIC GEOMETRY.

Third Class Year, June 2, 1902.

1. Construct the locus $y = \sin x$.
2 Find the equation of a straight line in terms of its intercepts.
3. Find the angle between $y = mx + c$ and $y = m'x + b$. Show the relation between m and m' if the lines are perpendicular.
4. Find the equation of the tangent to the circle $x^2 + y^2 = r^2$ at the point (x', y').

5. Find the general form of the polar equation of the circle.

6. What does the equation of the equilateral hyperbola, $x^2 - y^2 = a^2$, become if the axes are turned through—45°?

7. Find the equation of the ellipse, having given the foci and the constant sum $2a$.

8. Draw a tangent and a normal through a given point on an ellipse.

9. Prove the equation of the director circle of an hyperbola to be $x^2 + y^2 = a^2 - b^2$

10. Define the Cycloid and find its equation.

LITERATURE—Third Year Class.

Paper Set in February, 1902.

I.—Define: Drama; Epic; Tragedy; Comedy.

II.—Define: Complicating Forces; Resolving Forces; Climax; Catastrophe.

III.—Give an outline for analyzing a drama.

IV.—Enumerate the complicating and the resolving forces in "Macbeth," and locate the climax.

V.—From what source did Shakespeare get the story of "Macbeth," and what changes did he introduce in dramatizing it?

VI.—Discuss the metrical forms found in the play. Is there any prose? Discuss.

VII.—What is the general opinion as to the authorship of the play, i. e., the authorship of the whole play?

VIII.—Mention one or two events or speeches that are intended to prepare for more important events.

IX.—Write a brief sketch of the life of Shakespeare.

X.—Explain:

(a) "Paddock calls.
Anon."

(b) "Like valour's minion, carved out his passage."

(c) "To all and him we thirst,
And all to all."

(d) "Ere to black Hecate's summons
The shard-borne beetle with his drowsy hums
Hath rung night's yawning peal——"

(e) "And some I see
That two-fold balls and treble sceptres carry."

XI.—(a) When does Lady Macbeth's *work* in the play end? (b) What characters has Shakespeare made character-contrasts? (c) Is there a comedy element? If so, where? Why Why at that point? (d) Who is the dominating character in the earlier part of the play, and who in the latter part?

XII.—Write a theme of not less than three paragraphs upon one of the following subjects:
(a) Lady Macbeth as Queen.
(b) Lady Macbeth as Wife.
(c) One of the Minor Characters.

Paper Set in June, 1902.

I.—When, where, and in what political situation was the speech on "Conciliation" delivered? Into what divisions have we resolved it? What was the orator's Proposition? What, his Purpose? How did he propose to carry his purpose into effect?

II.—Mention three examples of allusion or of other figures of speech.

III.—Outline the "Statement of Facts."

IV.—In the early part of the speech, what reasons does Burke allege against the employment of force? Had he chosen to place these reasons elsewhere, what would have been the proper place for them? Why?

V.—Write a short sketch of Milton's life.

VI.—What persons, places or events are alluded to in the following lines:
(a) "For Lycidas is dead, dead ere his prime,"
(b) "For we were nursed upon the self same hill,
Fed the same flock by fountain, shade, and rill."

VII.—Explain or comment upon the meaning of the following words or phrases:
(a) *Once more*, in "Yet once more, O ye laurels——:"
(b) buxom; (c) Friar's lantern; (d) weeds of peace; (e) massy proof; (f) curfew; (g) storied windows richly dight; (h) ruth; (i) darkest grain.

VIII.—What do you consider Milton's relations to the speakers in "L'Allegro" and "Il Penseroso" to be? Discuss briefly.

IX.—(a) Give a concise description of a Mask. (b) What do you consider the most dramatic scene in "Comus"? Why?

X.—Quote a passage of not less than ten verses from each of the poems we have studied.

SPECIMEN ENTRANCE EXAMINATION PAPERS SET FOR PUPILS OTHER THAN THOSE ENTERING FROM THE GRAMMAR SCHOOLS.

Spelling and Penmanship.

Writing from dictation a paragraph or two of some standard text—Irving's Rip Van Winkle or Bancroft's United States History.

Grammar.

I.—Use each part of speech in a different sentence, indicating the part of speech used in each sentence by underscoring and naming it.

II.—Define and give an example of a simple sentence, of a complex sentence, and of a compound sentence.

III.—Parse the underscored words in the following sentence:

"By not <u>heeding</u> the <u>counsels</u> of our elders, <u>how</u> often do we <u>lose</u> <u>what</u> we should gain."

IV.—Analyze the following sentence:

"If we send the sailors a message in time, they will help us when the savages attack us."

V.—Write sentences illustrating the correct use of any perfect tense of the following verbs: sit, set, seat, lie, lay, write, go.

Composition.

The subject set is a description of some well-known place or object, or an account of some historical event.

United States History.

I.—What country was each of the following explorers serving when he came to America, and what territory did he discover or explore: Columbus, De Soto, Drake, Cartier, Da Gama.

II.—Name the principal causes and the principal results of the French and Indian War.

III.—State several causes of the Revolutionary War.

IV.—What were the "Articles of Confederation," and why, and by what, were they superseded?

V.—What is meant by "The Missouri Compromise"?

VI.—Give a short account of the "Nullification" incident.

VII.—What was the most important result of the Mexican War?

VIII.—Name the principal causes of the Civil War. Who commanded on each side at Gettysburg? Why was the battle of Gettysburg so important?

IX.—What reason did the United States assign for going to war with Spain in 1898? What territory did the United States acquire as a result of that war?

Arithmetic.

1. Face of note, \$450; date, Jan. 4, 1889; time 30 days. Find the proceeds of the note if it is discounted at bank on February 1, at 6%.

2. Two vessels sail from the same port; one due north at rate of 8 miles per hour, and the other due east at rate of 6 miles per hour. How far are they apart at the expiration of 5 hours?

3. How many lengths of rail of 30 feet each will be required to lay a double track of 10 miles, allowing $\frac{7}{100}$% for expansion?

4. If 10% of the power of a 40 horse-power engine is lost in transmission and still 20% more power than is required is furnished to a machine, what power is required by the machine?

5. A piece of land 35 rods long and 7 rods wide is divided into 5 square lots. What will be the cost of the boundary and the cross fences at \$2.12½ per rod?

Algebra.

1. (a) Simplify $\frac{x+2}{2} - \frac{x}{x+2} - \frac{x^3 - 2x_2}{2x^2 - 8}$.

(b) If $R = 5a + 4b - bc$, $S = -3a - 9b + 7c$, $T = 20a + 7b$, $U = 13a - 5b + 9c$, find value of $R - (S + T) + U$.

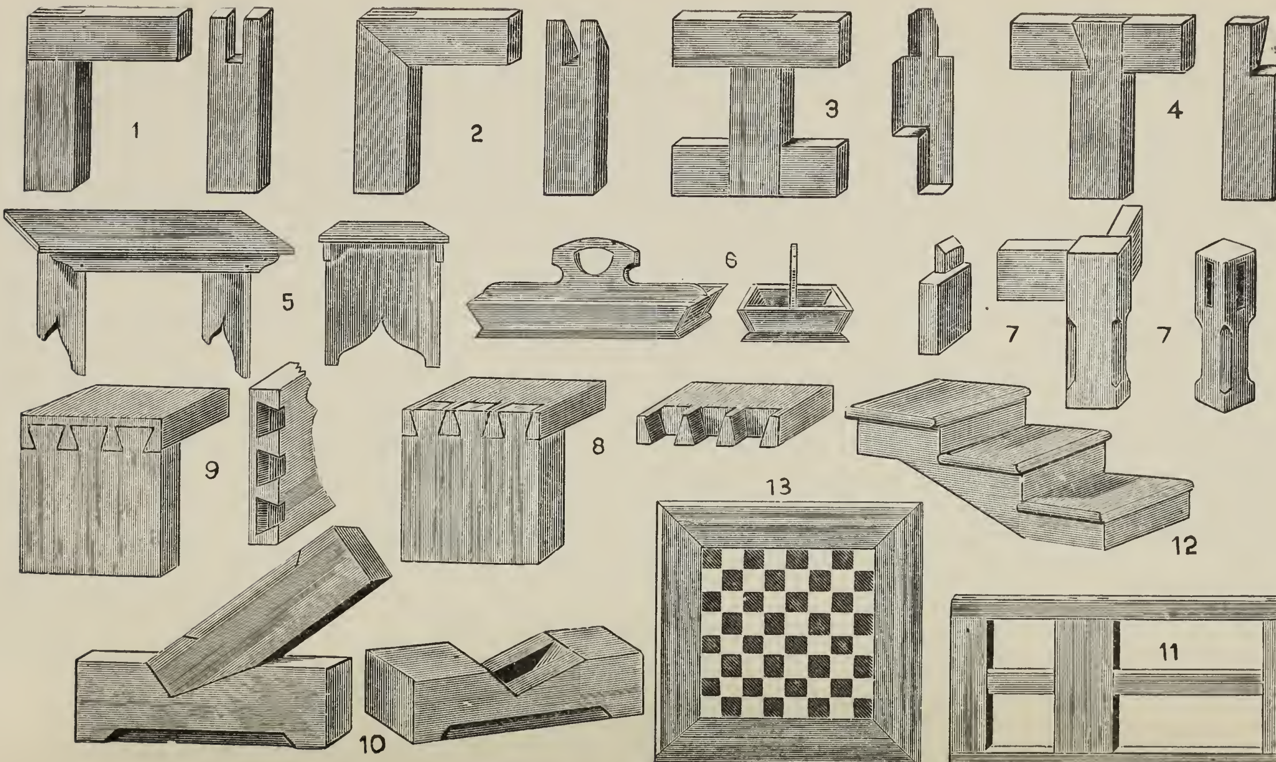
2. There are 150 coins, consisting of half-dollars and quarters, in a bag. If the value of the coins is \$58.50, find the number of each kind.

3. Given $\frac{7+x}{5} - \frac{2x-y}{4} = 3y - 5$, $\frac{5y-7}{2} + \frac{4x-3}{6} = 18 - 5x$, find the values of x and y.

4. Forty-six tons of goods are to be carried in carts and wagons, and it is found that 20 wagons and 14 carts, or 13 wagons and 9 carts, will be required. How many tons can each vehicle carry?

5. Separate into simplest factors: $x^2 - xy - 6y^2$; $x^6 - a^6$; $8x^2 + 13x - 6$.

6. What is the value of x in the equation $\frac{x-3}{x+4} + \frac{x-4}{2(x-1)} = \frac{1}{2}$?



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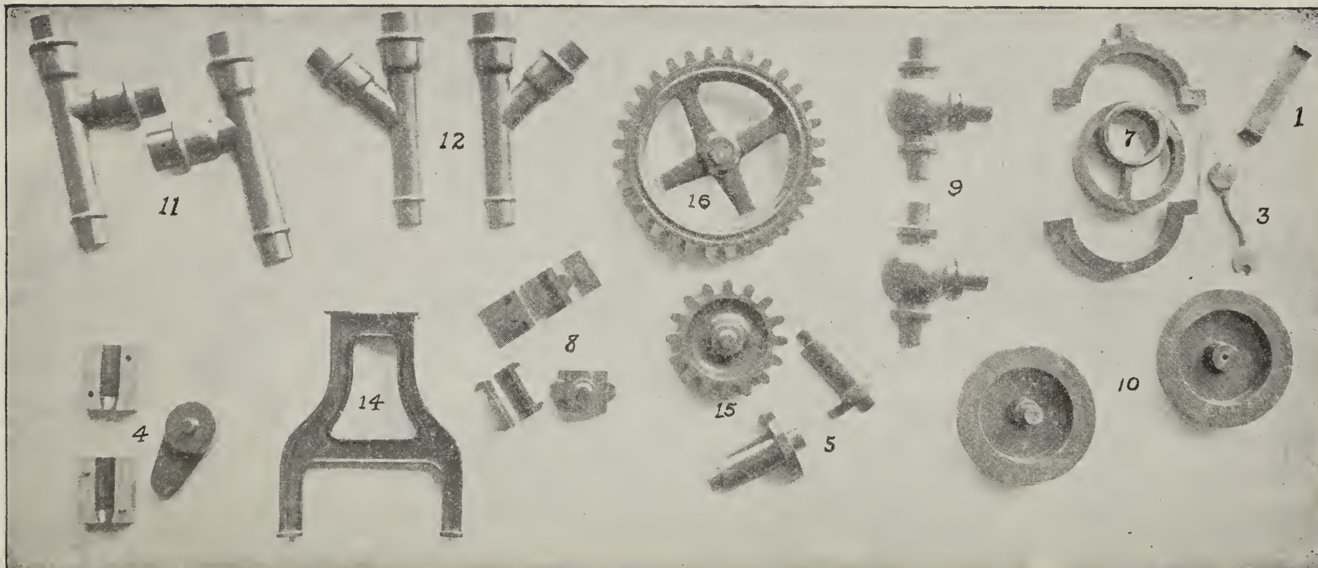

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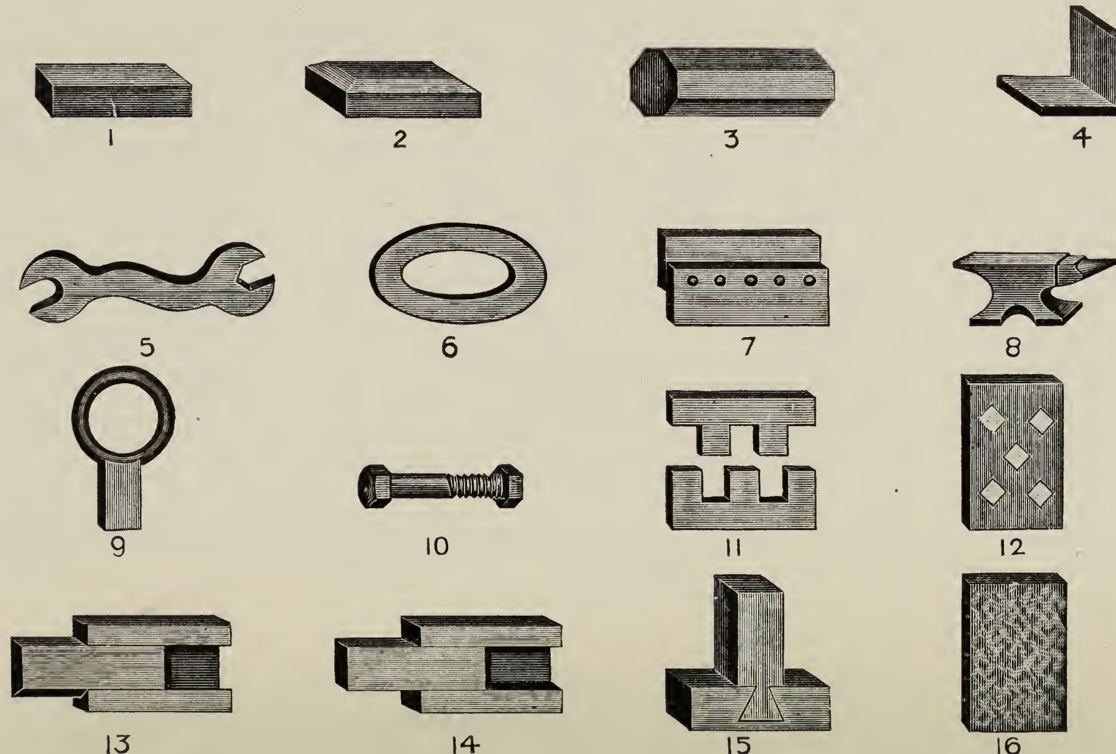

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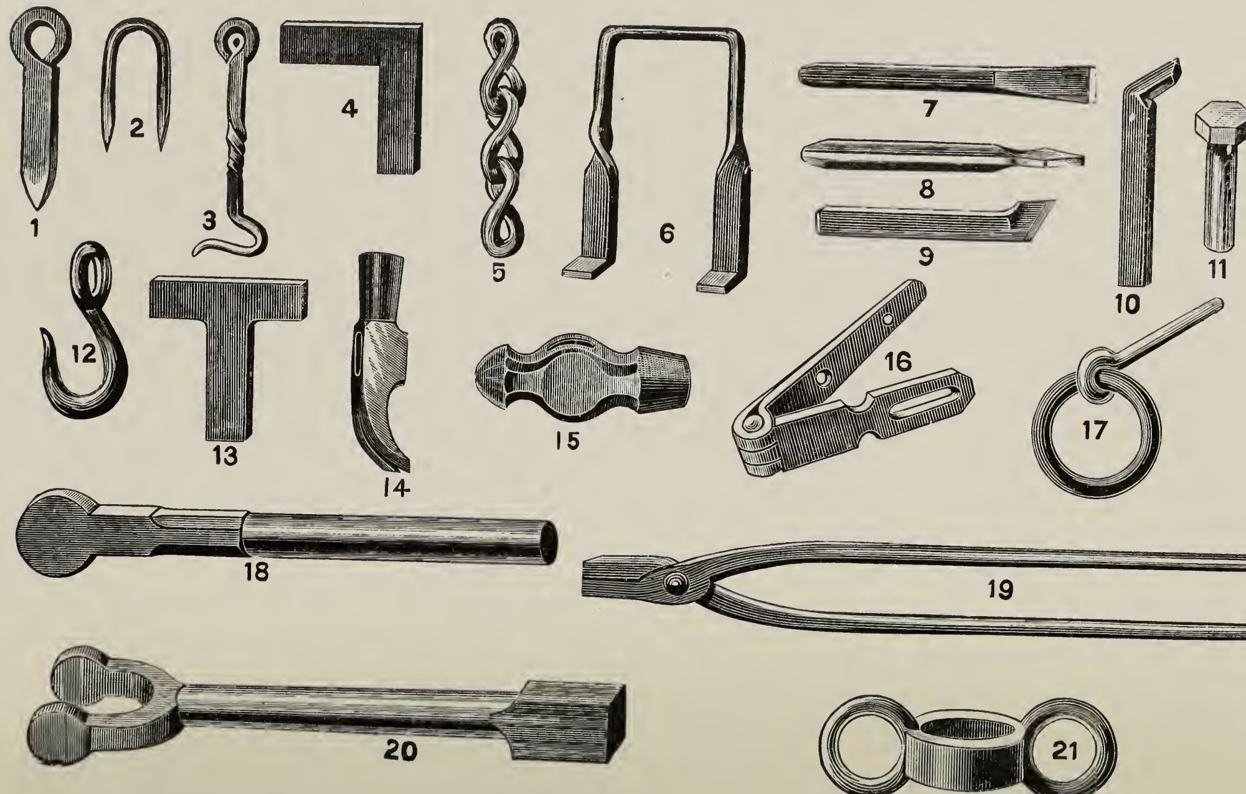

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